LEEDS PHILOSOPHICAL AND LITERARY SOCIETY

MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. LVII. DECEMBER 11, 1896. No. 2

A. A. COMMON, LL.D., F.R.S., President, in the Chair.

George Alexander Sime Atkinson, 238 Newport Road, Cardiff, South Wales; and
John Burt Trivett, Trigonometrical Survey of New South Wales, Sydney, N.S. Wales, Australia,

were balloted for and duly elected Fellows of the Society.

The following Candidates were proposed for election, the name of the proposers from personal knowledge being appended:—

George Banks, 4 John Street, Bedford Row, W.C. (proposed by C. A. Taylor);
John Charles Clancey, F.R.G.S., F.S.I., Assistant Director of Land Records and Agriculture, Burma, 7 Grafton Square, Clapham Common, S.W. (proposed by John Coles);
William Fraser Doak, M.A., Assistant, *Nautical Almanac* Office, 3 Verulam Buildings, Gray's Inn, W.C. (proposed by A. M. W. Downing);
Rev. Edward Spry Leverton, M.A., School House, Kirkham, Lancashire (proposed by Edwin Dunkin);
Ernest Frederick John Love, M.A., Lecturer in Physics in the University of Melbourne (proposed by Sir R. S. Ball);

William Arthur Smith, Merchant, 74 Hagley Road, Edgbaston, and 94 Charlotte Street, Birmingham (proposed by W. J. Lancaster); and

Edward Weldon, Merchant, 10 Morden Road, Blackheath, S.E. (proposed by H. P. Hollis).

Sixty-four presents were announced as having been received since the last meeting, including, amongst others :—

Sir G. B. Airy, Autobiography, presented by W. T. Lynn; W. Brennand, Hindu Astronomy, presented by R. Narayan Rai Bahadur; Charles Pritchard, Memoirs of his Life &c., presented by Miss Pritchard; Eclipse of 1860, M.S. observations, by C. Pritchard, and scrap-book of letters, drawings, &c., by J. Bonomi, presented by the executors of the late Professor Pritchard; G. V. Schiaparelli, Osservazioni del pianeta Marte Memorie IV., presented by the Author; Seven enlargements from lunar negatives taken at the Lick Observatory, presented by Dr. Weinek.

NOTICE TO FELLOWS.

THERE will be a Special General Meeting of the Society on 1897 January 8, at 9.45 P.M., after the Ordinary Meeting, to consider a proposal of the Council to alter Bye-laws 69 to 74 as follows :—

That Bye-laws 69 to 74 be altered by the addition of the word "gold" before the word "medal."

The Bye-laws in question at present read thus :—

EXTRACT FROM THE BYE-LAWS.

SECTION XVI.—*Of Awarding the Medal.*

69. No more than one medal shall be awarded or given during the course of any one year.

70. At the regular meeting of the Council, in the month of November in every year, the Council shall (prior to any other business) take into their consideration the propriety and expediency of awarding such medal ; and the name of every person who may be proposed and seconded as deserving the same shall be entered in the Minute-book.

71. Whenever more than one person shall have been proposed, the Council shall, at their regular meeting in December, select one of the persons so proposed to be submitted to the Council in January following on the question whether he shall or shall not receive the medal.

72. At the regular meeting of the Council in January following, the Council shall decide whether the nominee then before the Council shall or shall not receive the medal.

73. No medal shall be awarded in any other way than in the manner and at the time above prescribed ; nor unless three-fourths at least of the Members of the Council present shall agree thereto.

74. Notwithstanding the preceding Bye-laws, in cases where two or more persons have been jointly concerned in the production of any scientific treatise, or the carrying out of any research, work, or discovery, or have been the simultaneous but

independent authors of any such treatise, work, research, or discovery, the Council may, under these circumstances, receive the nomination of such two or more persons as joint recipients of the medal, and proceed thereupon in like manner as above mentioned with respect to the names of separate persons; and should the medal be ultimately awarded to such joint authors, workers, or discoverers, an impression of the medal shall be provided for and given to each of such joint recipients.

It will be seen that the above alteration will make it possible to award a Silver or Bronze Medal in addition to the Gold Medal. The Council now desire to award a Bronze Medal at intervals in accordance with the provisions of a Trust accepted by the Society in 1861 on terms which are specified in the extracts given below.

THE HANNAH JACKSON (*NÉE* GWILT) GIFT.

Extract from the Minutes of the Council of the Royal Astronomical Society, 1861 *June* 14.

The following proposal from Mrs. Hannah Jackson was received:—

"To the Royal Astronomical Society.

"I desire to give the sum of three hundred pounds stock now standing in my name in the books of the Bank of England to the intent that the same may be a reversionary gift into the names of the proper authorities for the time being of the Royal Astronomical Society of London, to be held upon trust for ever to pay and apply the dividends thereof, either annually or every two years, as they shall think fit, for the encouragement from time to time of any person writing the best astronomical work, or in any other way advancing astronomy, either by the invention of a new astronomical instrument or by the discovery of any new heavenly body. And I hereby desire that if, in the opinion of the said Society, the person writing such work or making such invention or discovery as aforesaid shall prefer the reward, they may choose the interest of the sum aforesaid in money or in a Gold Medal, and that the Gift shall be called the 'Hannah Jackson (*née* Gwilt) Gift.'

"I wish to receive the interest of the three hundred pounds stock without any difficulty during my life, but at the termination thereof, then to be held and applied as aforesaid for the purpose before named.

"Yours respectfully,
(Signed) "HANNAH JACKSON,
"*née* GWILT.

"P.S.—And I particularly wish that the gift may be completed without delay, as in a few weeks I propose going to Germany, and it will be very uncertain when I may return, and it is desirable to be done before then."

A discussion followed on the terms of Mrs. Jackson's proposal, and the form in which it could be received. The following resolutions were put:—

1. That in the event of Mrs. Jackson's offer being accepted the limit of the term of the accumulation of the interest be extended to seven years; proposed by Mr. Airy, seconded by Mr. Adams, and carried.

2. That it be permitted to apply the accumulated interest to the gift of a medal, or money, or of both; proposed by Mr. Airy, seconded by Mr. Walker, and carried.

3. That the objects of reward be the writing of an astronomical work or memoir, the invention or improvement of an astronomical instrument, the discovery of a new heavenly body, or the promotion in any other way of the science of astronomy; proposed by Mr. Airy, seconded by Mr. De la Rue, and carried.

4. That, subject to the above, the gift be accepted; proposed by Mr. Airy and seconded by Mr. Vignoles.

The following was proposed by way of amendment:—

That it be represented to Mrs. Jackson that it is desirable that such donations as hers should be as much as possible unfettered with conditions of application, and that Mrs. Jackson be asked if she would be willing to leave her fund as a special part of the funded property of the Society, with power to the Council to apply the interest as they may see fit from time to time; proposed by Mr. Carrington, seconded by Mr. Cayley, and negatived.

Resolution 4 was then put and carried unanimously.

Mrs. Jackson was then introduced to the Council, and the first three resolutions read and explained to her, when she gave her unqualified assent to the modifications introduced into her original proposal. The mode of transfer was arranged to be as follows:—Mrs. Jackson expressed her [intention] of directing her broker to transfer 300*l.* New 3 per cent. Stock now standing in her name in the books of the Bank of England to the Royal Astronomical Society, and to transmit the notice of the transfer thereof to the Treasurer of the Society, who would call at the Bank and accept the stock in the name of the Society, it being understood that a sum equal to the interest should be annually payable to Mrs. Jackson during her lifetime. Mrs. Jackson was also informed that the Council with pleasure acceded to her request that the *Monthly Notices* should be sent to her (gratis). She was further informed that her name would be enrolled in the list of benefactors.

Extract from the Annual Report of the Council, 1862 February (*Monthly Notices*, vol. xxii. No. 4).

The Council have to announce the receipt of a handsome reversionary gift. Mrs. Hannah Jackson has made over 300*l.* stock, reserving the dividends during her life, for the promotion of astronomy by rewards to be given in the name of "Hannah Jackson, *née* Gwilt." The conditions, including some slight modifications to which Mrs. Jackson at once consented on the suggestion of the Council, are as follows :—When the endowment takes effect, the accumulations of income, for any term not exceeding seven years, are, at the discretion of the Council, to be from time to time given in the form of a medal, or of money, or of both to the writer of any astronomical work or memoir, the inventor or improver of any astronomical instrument, the discoverer of any new heavenly body, or the promoter in any other way of the science of astronomy. The Council invite the Fellows to return thanks to Mrs. Jackson, not only for this very munificent gift, but for the judgment shown in allowing the mode of employment to be unfettered by any restrictions which might possibly diminish its utility.

Mrs. Jackson (or, as she styled herself latterly, Mrs. Jackson-Gwilt) died on 1893 December 1, and dividends were paid her up to that date. Since that time they have been accumulating, and there is now about 26*l.* in the treasurer's hands. Meanwhile the mode of awarding the Gift has been under consideration by the Council, and the following resolutions have been passed by them :—

1. That the award be called the "Hannah Jackson (*née* Gwilt) Gift."
2. That it consist of a money grant and a bronze medal.
3. That the design for the medal be a portrait of Sir William Herschel on the obverse, with allegorical design on the reverse, and be about 3 inches in diameter.
4. That the Gift be awarded at intervals of not less than three nor more than seven years.
5. That Bye-laws 69 to 74 be altered by the addition of the word "gold" before the word "medal."

It will be seen from the above extracts from the minutes of Council that—

Resolution 1 is necessary by the terms of the Trust, and

Resolution 2 was definitely contemplated at the time of acceptance of the Trust.

In accordance with Resolution 3, a design for a medal has been prepared by Miss Casella, and is now at the Society's rooms.

Resolution 4 is in accordance with the spirit of the resolution adopted at the time of acceptance of the Trust.

For Resolution 5 a General Meeting of the Society is necessary.

The proposed amendment of the Bye-laws is purely formal, no new principle being involved, since the general principle of the award of another medal was adopted by the Society in the adoption of the report of the Council for 1862, as quoted above. The amendment might have been considered at the Annual General Meeting in February next; but as it is proposed to make the first award of this Gift at that Annual Meeting, it is desirable to secure this alteration in the Bye-laws beforehand. Under these circumstances the Council resolved at their meeting on December 11 to call a Special General Meeting for 1897 January 8, as above, in accordance with Bye-laws 52, 49, and 51, which read as follows :—

52. Whenever the Council may think it advisable to propose the enactment of any new Bye-law, or the alteration or repeal of any existing Bye-law, they shall recommend the same to the Society at the Annual General Meeting next ensuing, or at a Special General Meeting convened for that purpose.

49. The Council may at any time call a Special General Meeting of the Society when it seems to them to be necessary.

51. A week's notice shall be sent to every Fellow residing in or near London of the time of any Special General Meeting, and of the business for which it is summoned, and no business shall be brought forward at such Meeting except what has been so notified.

E. W. Maunder,
H. H. Turner, } *Secretaries.*

The Total Solar Eclipse of 1896 *August* 9.

(*Note by the Secretaries.*)

A paper has been communicated to the Society by the Joint Permanent Eclipse Committee of the Royal Society and Royal Astronomical Societies on observations of the above eclipse, and will appear in the *Memoirs*. The observations were made by Mr. E. J. Stone, Radcliffe Observer, who was enabled to occupy a station in Novaya Zemlya by the private enterprise and liberality of Sir George Baden-Powell, who had conveyed the observers there in his own yacht and at his own expense.

Mr. Stone read his paper to the meeting on December 11, and exhibited the photographic spectra of prominences which he had obtained with a wide slit. He further showed photographs of the spectrum of the outer corona taken during totality and up to 60 seconds afterwards (the general character of the spectrum remaining the same), and some outline drawings of portions of the corona.

After Mr. Stone had read his paper, Mr. W. Shackleton, who had also accompanied the expedition on the invitation of Sir G. Baden-Powell, showed some photographs of the spectrum of the chromosphere and inner corona, taken with an objective prism. One of these, taken just before totality, showed a series of bright lines in the positions of the Fraunhofer lines, and was presumably the spectrum of the so-called "reversing layer."

Sir George Baden-Powell had himself assisted Mr. Shackleton with the coronagraph during totality, exposing the plates on the Sun. He showed the series of photographs of the corona, and gave an account of the circumstances which led him to organise the expedition, and continued :—

"Perhaps I may say a word or two as to how we secured those wonderful astronomical results which Mr. Stone and Mr. Shackleton have so well described.

"They told you much, but on one important matter they were silent. They did not tell of the very arduous work through which they went—how they toiled in the face of cold, fog, rain, sleet, and wind to get the instruments set up, protected, and adjusted. Without all that devoted work and exposure there could and would have been no results.

"For instance, the Siderostat falsely worked quite well almost up to the time of totality, and then we could see, to our horror, on the ground glass in the coronagraph the image of the Sun travelling steadily off the field. Mr. Shackleton energetically attacked the clockwork adjustments, but still the image was refractory, and only just before totality did he say, 'Now she'll do!'

"Perhaps the happiest moment to me during the eclipse was after totality, and immediately all was bright and light again,

slipping in the ground glass and to my joy finding the image of the Sun still in the centre of the field.

"In going so far north I myself felt—perhaps because of the experiences of my respected uncle, Piazzi Smyth, on the Peak of Teneriffe—that much might be gained by this first setting up of really powerful instruments in so high a latitude, the atmosphere being, without doubt, *different* from that in lower latitudes, and especially in the tropics.

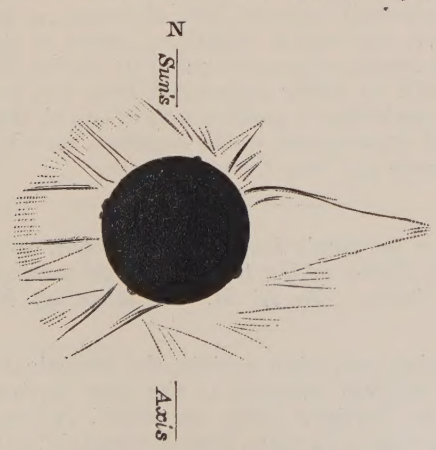
"I trust that our results, enhanced in value because the clerk of the weather saw fit to send clouds or rain to all the other stations scientifically occupied, will be of practical value in many ways, and especially, as it were, as stepping-stones between the photographic results first obtained in 1893 and those which will be secured in 1898."

Sir George Baden-Powell further expressed the opinion that, although he was glad to have been able to assist science by organising this expedition, it should not have been necessary to do so. Having had experience of the cost of such expeditions, he considered the amount placed at the disposal of the Committee was quite inadequate for the occupying of a proper number of stations; and he trusted it might be largely increased on future occasions. Should, however, the assistance of a yacht again be unavoidably necessary, he and Lady Baden-Powell would gladly again do all in their power, should they be free.

This generous offer was cordially acknowledged by the Fellows present.

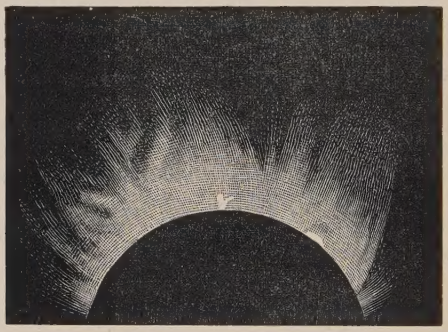
Mr. W. H. Wesley, Assistant Secretary to the Society, who has had great experience in drawing different coronas, made the following remarks on the corona of 1896 :—

"The resemblance between the corona of 1896, as shown on



Outline of Corona of 1885.

the Novaya Zemlya photographs, and that of 1886 is very striking—closer, in fact, than that between any two coronas of different years that have yet been photographed. It may be interesting also to compare the corona of 1896 with that of 1885 (eleven years before), and I therefore give a rough outline which I sketched some years ago from negatives taken in New Zealand, which have never been published. The corona of 1885 does not appear so much like that of 1896, as the long extension on the north-west, shown in the latter year and in 1886, is in 1885 much nearer the Equator—forming, in fact, an equatorial extension. The sketch has been oriented from indications on the original ; but should there be any mistake on this point, and the north pole of the Sun's axis in 1885 lie some 45° further west, the resemblance between the corona of that year and that of 1896 would be decidedly close.



Sketch of detail in the Corona of 1896.

"The corona photographs which have been taken in Novaya Zemlya are extremely beautiful, but, of course, no lantern slides can do justice to the original negatives. Some of the detail on the south-east quadrant appears to me of an unusual, if not unique, kind. This will be better understood from the rough sketch which I have made from a positive copy of one of the negatives ; but a study of the originals would doubtless reveal much more than can be made out from the copy."

Comparison of the Sun's Longitudes for 1901, *computed from Newcomb's Tables of the Sun with those computed from Le Verrier's Tables.* By A. M. W. Downing, M.A., D.Sc., F.R.S.

The following comparison exhibits the corrections to apparent longitudes of the Sun (referred to the mean equinox of date), taken from Le Verrier's *Tables du Soleil*, deduced from the corresponding longitudes taken from Newcomb's Tables at eight-day intervals during the year 1901.

The large annual term appearing in the comparison is due mainly to the corrections for eccentricity and longitude of perigee, which (as is pointed out in *Monthly Notices*, vol. lvi. No. 2, page 69) amount to

$$+0''\cdot40 \sin g - 0''\cdot21 \cos g,$$

where g is the mean anomaly.

The outstanding residuals (after application of the above) are traceable to differences in the tables of perturbations.

Longitudes of Sun 1901.

Corrections to Le Verrier's Tables.

Day.	Correction.	Day.	Correction.
	″		″
Jan. 2	−0·86	July 5	+0·02
10	−0·64	13	−0·03
18	−0·59	21	−0·16
26	−0·69	29	−0·21
Feb. 3	−0·49	Aug. 6	−0·16
11	−0·39	14	−0·28
19	−0·40	22	−0·45
27	−0·38	30	−0·45
Mar. 7	−0·22	Sept. 7	−0·51
15	−0·14	15	−0·67
23	−0·20	23	−0·77
31	−0·10	Oct. 1	−0·72
Apr. 8	+0·01	9	−0·83
16	−0·01	17	−0·95
24	−0·04	25	−1·05
May 2	0·00	Nov. 2	−0·94
10	+0·08	10	−1·05
18	+0·06	18	−1·12
26	+0·01	26	−1·00
June 3	+0·13	Dec. 4	−0·92
11	+0·19	12	−0·95
19	+0·02	20	−0·95
27	−0·09		−0·72

Nautical Almanac Office:
1896 *December* 8.

On Systematic Errors in observing Right Ascensions of Nebulæ.

By J. L. E. Dreyer, Ph.D.

Although a great number of micrometer measures of nebulæ have been made during the last forty years, it has hitherto not been found feasible to combine the results into a general catalogue of accurate positions of nebulæ, owing to the systematic errors with which the observations of Right Ascension are more or less affected. Attention was first drawn to these errors by Julius Schmidt (*Astr. Nachr.*, No. 1463), who pointed out that Schönfeld's Right Ascensions, deduced from observations made with an annular micrometer, were systematically smaller than those found by himself with a similar micrometer, and, as was soon afterwards found, smaller than those of several other observers. In 1875, when the extensive and valuable series of filar-micrometer observations by Schultz had been published, I compared them with Schönfeld's, using only those objects which the two observers had compared with the same star, and I found from 113 objects the very pronounced difference Schönfeld I. − Schultz = $-0^{s}.34$. It appeared, furthermore, as already noticed by Schmidt, that the difference depended to a great extent on the degree of condensation of the objects. Dividing these into three classes according as they had a sharp nucleus, were fairly condensed or wanting any condensation, the difference was found to be *

I.	$\Delta\alpha \cos\delta = -0^{s}.15$	from 32 neb.
II.	$-0^{s}.39$	„ 53 „
III.	$-0^{s}.44$	„ 28 „

Shortly afterwards Schönfeld published his second series of measures, and, as might have been expected, the knowledge that he observed transits of nebulous objects too early led to a reduction of his personal error, the difference Schönfeld II. − Schultz being $= -0^{s}.15$. From this and the former difference there results Sch. I. − II. $= -0^{s}.19$, while the direct comparison between the two series gave $-0^{s}.21$, and an indirect comparison by means of Rümker's measures gave $-0^{s}.25$.†

Every series of observations which has been published since has confirmed the reality of these errors in the observed Right Ascensions, while differences in declination between various observers appear to be mere accumulations of accidental errors. Thus M. d'Engelhardt gives the following differences between

* *Vierteljahrsschrift d. Astr. Ges.*, vol. x. p. 72.
† *Ibid.*, vol. xi. p. 274.

his own measures and those of a number of other observers, which are in good accordance with the differences quoted above.*

		s		
Sch. I.	—Eng.	= −0·55	57	objects
Sch. II.	„	−0·39	60	„
Schultz	„	−0·21	70	„
Vogel	„	−0·18	50	„
Rümker	„	−0·27	31	„
Engelmann	„	−0·04	46	„
Auwers	„	−0·18	12	„
Oppolzer	„	−0·15	7	„
Ginzel	„	0·00	14	„
Dreyer	„	−0·47	22	„
Porter	„	−0·42	16	„
Weinek	„	+0·22	14	„
Gruss	„	−0·28	14	„
Kempf	„	−0·26	33	„

The mean of these fourteen equations is $-0^s\cdot23$, which tends to show that Schultz's measures are probably nearly free from these systematic errors. It will also be seen that my own error lies between those of Schönfeld's two series, as I have also found by direct comparison.†

		s		
Schönfeld	I. − Dreyer	= −0·11	27	neb.
„	II. „	= +0·04	38	„

In the summer of 1895 it occurred to me that it might be possible for an observer with a filar micrometer to determine his own personal error in a very simple manner. As there is every reason to believe that measures of difference of declination between a nebula and a star are practically free from systematic error (or at all events from any errors approaching in magnitude to those of the transit observations), a difference of Right Ascension between a nebula and an adjacent star might be measured both by transits and by the micrometer screw. Assuming, then, that the screw measures represented the true $\Delta\alpha$, the difference between them and the transits would directly give the error of the latter. In order to be perfectly free from bias I postponed the carrying out of this idea for some months, and abstained in the meanwhile from reading anything about measures of nebulæ. The reduction of the observations, and even the copying of them

* *Observations Astronomiques*, t. iii. p. 28.
† *Trans. Royal Irish Acad.*, vol. xxx. p. 522.

PHILOSOPHICAL
AND LITERARY SOCIETY.

from the rough note-book into the volume of refractor observations, was also deferred until the final close of the series of measures ; and, as I had even forgotten the signs of the differences between other observers and myself, I feel perfectly convinced that the results of these measures are altogether free from any conscious bias.

The observations given in the following table were made with the 10-inch refractor and the same filar micrometer with which my previous measures were taken. T is the $\Delta\alpha$ (nebula minus star) observed by transits with eye and ear, from ten to sixteen single-wire transits being generally taken ; M is the same $\Delta\alpha$ measured four or five times with the screws while the clock was carrying the telescope along. In the column "Cond." the nebulæ are classified according to whether they have a fairly sharp nucleus (1), or are more or less devoid of condensation (2). The column "Star" gives the magnitude of the comparison star and its place relative to the nebula. The $\Delta\delta$ was generally small. I give the results in full, as they may eventually be of use in determining proper motions of the objects.

G.C.	Date.	T.	M.	M−T.	Cond.	Star.	Notes.
		s	s	s			
307	4 1 96	+20·12	+20·13	+0·01	1	10·5, n p	Good object.
1904	1 4 96	+12·99	+13·42	+0·43	2	12, s p	
2038	1 4 96	−34·93	−35·43	+0·50	1	11, f	
2041	1 4 96	− 6·02	− 5·88	+0·14	1	11, n f f	
2102	1 4 96	−19·82	−19·48	+0·34	2	10, s f	
3227	8 5 96	−39·09	−39·55	−0·46	1	10, s f f	
	12 5 96	−38·95	−39·05	−0·10	1		Not B, twilight and haze.
3615	8 5 96	+37·57	+37·69	+0·12	1	11, p	
	12 5 96	+37·67	+37·71	+0·04	1		
4473	5 9 96	+44·53	+44·76	+0·23	2	9·5, p	Very soft condens.
4499	1 9 96	−15·95	−16·06	−0·11	2	9, s f	Almost like a cluster.
	5 9 96	−16·07	−15·97	+0·10	2		Nice object.
4510	10 9 96	+14·98	+15·08	+0·10	2	11·5, p	
	11 9 96	+15·01	+15·18	+0·17	2	12, p	
4572	19 9 95	+53·97	+54·51	+0·54	2	9·0 p	
	21 9 95	+54·15	+54·69	+0·54	2		
4586	22 9 95	+ 7·34	+ 7·41	+0·07	2	9, s p p	
	16 10 95	+ 7·36	+ 7·32	−0·04	2		
4608	22 9 95	−18·62	−18·55	+0·07	2	9·5, f	
	17 10 95	−19·34	−18·70	+0·64	2		L, v l b M, l E p f (✱ is s p one of 2).
4625	20 9 95	+46·53	+46·73	+0·20	1	8·5, s p	
	21 9 95	+46·72	+47·04	+0·32	1		

G.C.	Date.	T.	M.	M—T.	Cond.	Star.	Notes.
		s	s	s			
4678	19 9 95	−11·65	−11·08	+0·57	2	9·5, n f	
	21 9 95	−11·48	−10·79	+0·69	2		Good object to measure.
4734	20 9 95	+12·10	+12 29	+0·19	1	10, n n p	
	22 9 95	+11·68	+12·22	+0·54	1	9·5, n n p	
4760	1 9 96	−13·37	−12·91	+0·46	2	11, s f	B, p L.
	5 9 96	−13 42	−13·07	+0·35	2		
4808	22 10 95	− 6·13	− 6·10	+0·03	1	10, n f	p F, p L, m b M.
4815	10 9 96	−33·78	−34·14	−0·36	1	11, n f	
	11 9 96	−34·01	−34·13	−0·12	1		
4821	16 10 95	− 3·37	− 2·97	+0·40	1	10, s s f	s m b M.
	17 10 95	− 3·31	− 3·22	+0·09	1		
4824	17 10 95	+18 32	+18 57	+0·25	2	Same ✶	
4879	17 10 95	−10·37	−10·29	+0 08	2	10, f	
	18 10 95	−10·34	−10·39	−0·05	2		
4880	17 10 95	−19·36	−18·81	+0·45	2	9, f	Rather F for B wires.
	18 10 95	−19·76	−18·74	+1·02	2		v l condens., diffused.
4921	22 10 95	+25·44	+25·81	+0·37	1	8·5, n p	p B, p L, m b M.
	14 11 95	+25·15	+25·77	+0·62	1		p F.
4939	1 11 96	−26·70	−26·75	−0·05	2	8, n f f	Brighter towards a point nearer s f edge.
	3 11 96	−26 67	−26 46	+0·19	2	7·5, f	
4966	22 10 95	+ 8·63	+ 8·75	+0·12	1	9·5, p	
	11 12 95	+ 8·63	+ 8·44	−0·19	1		
5020	1 11 96	+39·70	+40·16	+0·46	2	10, s p	[n p]
	4 11 96	+39·62	+39·50	−0·12	2	11, n p	✶ almost in line with 2 neb.
5022	4 11 96	+60·23	+60·32	+0·09	2	Same ✶	
5029	5 11 96	+17·40	+17·41	+0·01	1	8·8, p	

The mean of the column M − T ought now to represent my personal error, and is

$$+0^{s}\cdot206$$

or $+0^{s}\cdot202$ of each value of M—T is multiplied by cos δ.

Taking the two classes of objects separately we get:

	s
For much condensed nebulæ	+0·118
For little condensed nebulæ	+0·277

The result of this investigation is, therefore, that I am, like Schönfeld, inclined to note the transits of nebulous objects too early, and that my error, like his, is much smaller for a nebula

with a good nucleus than for more diffused objects—which is only natural. Though I am not conscious of any peculiarity in my mode of observing, I am inclined to think that this error may arise from the fact that the nebula on approaching the illuminated wire becomes somewhat fainter, which may induce an observer to anticipate the actual moment of transit.

It is of interest to compare my results with those of a recent attempt by Dr. Mönnichmeyer, of Bonn, to deduce the corrections necessary to reduce various observations of nebulæ to a homogeneous system.* Dr. Mönnichmeyer, who has observed about two hundred nebulæ with an annular micrometer, first determined his own personal error in star transits, as far as it depends on magnitude, by observing stars of various magnitudes in the *Pleiades*, and comparing the results with Dr. Elkin's heliometer measures. This equation depending on magnitude he calls $\Delta H''_\alpha$. Supposing now that his nebular personal error is approximately represented by his stellar error thus found, then, if Schultz's and Vogel's results are practically free from systematic errors, the differences between their Right Ascensions and those of Dr. Mönnichmeyer ought to be equal to this ΔH_α. And even if the measures of Schultz and Vogel are affected by sensible errors, the said differences might still be represented by ΔH_α, if M's personal equation is a product of various sources of error, by some of which the observations of Schultz and Vogel are equally affected. In this case the ΔH_α would represent the reductions of M's observations to the "filar micrometric system of Schultz and Vogel"; and if all measures can be reduced to a common system, it will of course be of no consequence for future investigations of proper motion whether ΔH_α is to be considered as relative or absolute error. Assigning a certain stellar magnitude to every observed nebula, Dr. Mönnichmeyer divides the objects into classes according to the difference of magnitude between nebula and comparison star. From the difference "other observer minus Mönnichmeyer" ΔH_α is subtracted, and the difference is called $\Delta\alpha'$. This should be zero, if ΔH_α represents the reduction to a common system, and so it is in the cases of Schultz and Vogel. If not equal to zero, $\Delta\alpha'$ represents the personal error of the other observer. In this manner the following constant personal errors were found :—

	s		s
Schönfeld I.	+0·24	Engelhardt	−0·21
Schönfeld II.	+0·09	Kempf	+0·05
Dreyer	+0·14		

These observers seem, therefore, not to be sensibly influenced by the difference of magnitude between nebula and star. But Schmidt's Right Ascensions appear to be affected by approximately the same systematic errors as those of Dr. Mönnichmeyer

* *Veröffentlichungen der K. Sternwarte zu Bonn*, No. 1, "Beobachtungen von Nebelflecken am sechszölligen Refractor von Dr. C. Mönnichmeyer."

are, as Schmidt's error is $=\frac{4}{3}\ \Delta H_a$. Similarly Rümker's error is $=\frac{5}{4}\ \Delta H_a$, and Ginzel's $=2\ \Delta H_a$. As a final test of all these results, they were applied to the single differences betwen M and the various observers, and the mean $\Delta\alpha$ comes out as $0^s{\cdot}00$ or $0^s{\cdot}01$ in all cases except that of Ginzel, where it is $+0^s{\cdot}04$, so that his personal error as found by this investigation is a little too small, while the reduction to the Vogel-Schultz system in the other cases seems a perfect one. Though these results, considered as absolute personal errors, perhaps in some cases (*e.g.* in Schönfield's, where they seem rather smaller than we should have expected) may be a little modified by future investigations, the differences between them agree well with those found by direct comparison.

My own relation to Schultz may be made out in several ways, either by direct comparison or through the medium of other observers. I have already in the paper in the *Trans. R.I. Acad.* given the result of the direct comparison of twenty-six objects observed by Schultz and myself, viz. Schultz—Dreyer $= +0^s{\cdot}07$; but this is not entitled to any great weight, as twelve of the objects are well condensed and give $0^s{\cdot}00$, while only fourteen are slightly condensed and give $+0^s{\cdot}13$. The results of indirect comparison through four observers, with whom both Schultz and I have many objects in common, are probably much more reliable, and they agree closely *inter se*.

	s
Through Schönfeld I.	+0·23
,, ,, II.	+0·19
,, Engelhardt	+0·25
,, Mönnichmeyer	+0·18
Mean	+0·21

As this result for the difference Schultz-Dreyer is in perfect accordance with my absolute personal error as found from my recent observations, it may be assumed as well-established facts that Schultz's observations are practically free from systematic errors, and that my own absolute error in observing transits of nebulæ is very close to $+0^s{\cdot}2$. It is true that the value found by Dr. Mönnichmeyer for the latter quantity, $+0^s{\cdot}14$, is somewhat smaller ; but as it was only derived from nineteen objects, nearly all (by ill luck) having a strong central condensation, this smaller value is also in very good agreement with the absolute error ($+0^s{\cdot}12$) which I found for nebulæ with a well-marked nucleus.

We may therefore look forward to the ultimate determination of proper motions of nebulæ with more confidence than hitherto, as we are getting the systematic errors well under control. The fact must, however, not be lost sight of, that in applying corrections for personal error to the observed places

proper attention must be paid to the degree of condensation of the objects. But there is an obvious way of avoiding systematic errors altogether (except such as are well within the limit of accuracy attainable in such observations) by giving up observations of transits and measuring both $\Delta\alpha$ and $\Delta\delta$ by the micrometer screw. As this can only be done by selecting comparison stars among those visible in the same field with each nebula, and such stars in many cases cannot be observed on the meridian, observers will have to sacrifice the pleasure of putting together a list of Right Ascensions and Declinations of the nebulæ they have measured. But this small sacrifice will be well compensated by the avoidance of the difficulty of assigning to each object the proper amount of systematic error.

Armagh Observatory:
1896 *December.*

On the Inequality in the Apparent Diurnal Movement of Stars due to refraction, and a method of allowing for it in Astronomical Photography. By Prof. Arthur A. Rambaut, M.A., D.Sc.

It is obvious that the varying effect of refraction in the Earth's atmosphere to which the light of a star is subjected as its hour-angle changes will cause inequalities in its apparent diurnal movement, and that no uniform equatorial movement will enable a telescope to follow a star for long periods of time when the highest accuracy is aimed at.

The irregularities in the apparent motion of stars due to local and temporary changes in the refraction are well known to astronomers who have had experience in stellar photography, but I doubt whether the perfectly regular and systematic change as the star alters its position in the sky has received the attention on the part of astronomers which its importance seems to demand.

Speaking generally, the hour-angle of a star is diminished by the refraction when approaching its upper culmination, but to a continually decreasing extent, and consequently the motion of the star at this part of its course appears slower than it actually is. At first sight it might perhaps appear that the effect at the western side of the meridian would be of an exactly opposite kind, and that the stars at this part of their diurnal track would appear to move more rapidly than they actually do. But a moment's reflection will show that this is not the case, for the refraction throwing the apparent to the following side of the true image in this case, and the displacement continually increasing as the star sinks in the west, the apparent will fall ever more and more behind the true position.

Now this inequality in the apparent movement occasions a great part of the difficulty in making a telescope follow accurately for long periods of time, and necessitates most of the watching and guiding by hand which renders a long exposure so laborious and fatiguing. The equatorial movement of the instrument being a uniform one, it is impossible to rate an equatorial clock so as to follow a star with equal accuracy at all parts of its course. The changes in the refraction are, indeed, from one point of view so slow that in most cases the clock can be rated to follow a particular star with sensible accuracy for reasonable intervals of time; but no adjustment will suit all stars equally well, and to obtain the best results the rate of the clock ought in each case to be adjusted for the particular star under consideration, and if the exposure is prolonged the rate ought to be suitably altered from time to time.

As an example, I may state here, in order to show that the differences to which I refer are not negligible quantities, that if a clock were rated by the motion of a star at the zenith in these latitudes, it would gain more than one-thirtieth of a second of time each minute on a star crossing the meridian at declination $77\frac{1}{2}°$, which would cause the star to fall behind the cross wires at the rate of one-tenth of a second of *arc* per minute; a rate of displacement which would very soon make itself sensible in any telescope of moderate dimensions. At a distance from the meridian the differences would be greater; and if the exposure were continued for, say, four hours, it would require frequent hand correction, amounting in the aggregate to more than 24 seconds, to counteract its effect.

It will thus be seen that the varying effect of refraction at different parts of the sky upon the motion of a star is quite noticeable, and that if this disturbance could be removed the art of steering a photo-telescope so as to point continuously at a given star, which, under the most favourable circumstances, is no easy task, might be rendered much less exacting and severe.

My attention has been specially directed to this question by the fact that in the class of work to which I have devoted our telescope at the Observatory of Trinity College, Dublin, viz., the measurement of stellar parallax, it is often necessary to take photographs of star groups at considerable hour-angles when the effect of refraction is most noticeable. If the observer's object is merely to obtain pictures of star groups, the work can be so arranged that each object is photographed when it arrives at or near the meridian. Thus almost all Dr. Roberts' photographs were taken at small hour-angles. The photographs for the international photographic survey of the heavens are also taken close to the meridian, where the variation in the angular movement of stars is least felt.

It is different, however, when it is intended to utilise the plates for the detection of stellar parallax. In connection with this research, it is desirable that a large proportion of the photographs

of each object should be taken when the star is near the apses of its parallactic ellipse, and this condition often necessitates photographing a star at hour-angles of six hours or more.

I have thus been led to examine minutely the effect of refraction on the movement of a star; and since a method which enables good photographs to be taken comparatively easily at any altitude, provided the atmosphere is steady enough for good seeing, cannot fail to be useful, perhaps a description of the means I have been led to adopt for this purpose may prove of interest to many who are engaged in this or other branches of stellar photography.

Let us examine what the effect of refraction is. If we denote the apparent western hour-angle of a star by h, the effect of refraction in hour-angle by Δh, the right ascension by α, and the sidereal time by θ, we have

$$h = \theta - \alpha + \Delta h,$$
$$\frac{dh}{d\theta} = 1 + \frac{d\Delta h}{d\theta}.$$

Hence the expression $\frac{d\Delta h}{d\theta}$ measures the rate at which the apparent movement of a star gains on its mean movement or on sidereal time.

To calculate this quantity we have the equation:

$$\left.\begin{aligned} &\sin\eta \cot \Delta h = \cot \Delta\zeta \cos\delta - \sin\delta \cos\eta \\ \text{Also}\quad &\sin(\delta+\Delta\delta) = \sin\delta \cos\Delta\zeta + \cos\delta \sin\Delta\zeta \cos\eta \end{aligned}\right\} \quad . \quad . \quad . \quad . \quad (\alpha)$$

in which δ denotes the declination, ζ the zenith distance, and η the parallactic angle, of the star, and $\Delta\zeta$, Δh, and $\Delta\delta$ are the effects of refraction in ζ, h, and δ respectively. For our present purpose we may put $\Delta\zeta = \beta \tan\zeta$, β being a function of ζ and so small that we may neglect its square and higher powers.

Hence

$$\Delta h = \beta \tan\zeta \sin\eta \sec\delta = \beta.\psi, \text{ say.}$$

Differentiating, we find

$$\frac{d\Delta h}{a\theta} = \beta \frac{d\psi}{d\theta} + \psi \frac{d\beta}{d\theta}.$$

Except in the immediate vicinity of the horizon, the second term in this may be neglected,* and we get, therefore,

$$\frac{dh}{d\theta} = 1 + \beta \frac{d\psi}{d\theta}.$$

* See a paper in the *Astronomische Nachrichten*, No. 3,125, on "The Corrections for Refraction to Measures of Stellar Photographs."

Also by the ordinary formulæ of transformation, if ϕ denotes the latitude of the observatory, we have

$$\psi = -\frac{\cos\phi}{\cos\delta}\cdot\frac{\sin h}{\sin\delta\sin\phi+\cos\delta\cos\phi\cos h};$$

and therefore

$$\frac{dh}{d\theta}=1-\beta\,\frac{\cos\phi}{\cos\delta}\cdot\frac{\cos\delta\cos\phi+\sin\delta\sin\phi\cos h}{\{\sin\delta\sin\phi+\cos\delta\cos\phi\cos h\}^2}.$$

Assuming m, n, μ, ν such that

$$\tan m=\cot\phi\cos h \qquad \cot\mu=\tan\phi\cos h$$
$$\cot n=\sin m\tan h \qquad \cot\nu=\cos\mu\tan h$$

this may be written in the form

$$\frac{dh}{d\theta}=1-\beta\,\frac{\cos\phi}{\cos\delta}\cdot\frac{\sin\nu\sin(\mu+\delta)}{\sin^2 n\sin^2(m+\delta)} \quad . \quad . \quad . \quad . \quad . \quad (\beta)$$

If it were required that the telescope should follow the star with absolute precision, it would be necessary to construct a clockwork system which would drive the instrument at a rate varying continually with the hour-angle according to the law expressed by this formula (β). In practice, however, it is sufficient to alter the rate at intervals, the length of which will depend upon the rapidity of the changes in the refraction, provided always that the error thus introduced does not exceed a certain definite limit.

From the formula (β) I have computed the values of $\frac{dh}{d\theta}-1$ for every tenth degree in declination, and for every even hour in hour-angle, and from the quantities thus obtained I have drawn the series of curves in fig. 1, in which the abscissæ denote the gaining or losing rate of the star as compared with sidereal time, expressed in the usual way as so many seconds a day.

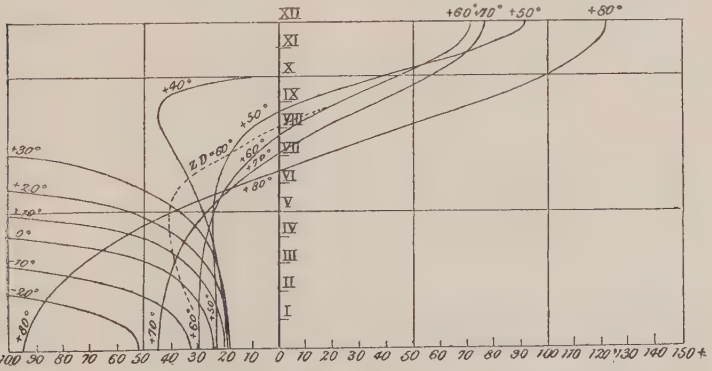


Fig. 1.

Now an examination of these curves shows that, even when the change in the rate of movement is most rapid, a uniform rate, *if suitably chosen*, will not in ten minutes introduce an error amounting to the one-twentieth of a second, which is about the limit within which the accidental errors of a good equatorial clock can be kept. This, then, would appear to be the limit of time for which, in cases of extremely rapid changes in the stars' movements, a uniform rate may be used. In most cases a longer interval is allowable.

If the exposure is prolonged beyond the period for which a uniform rate is permissible, it will be necessary to alter the rate from time to time in such a way that the algebraic sum of the errors thus introduced, alternately in excess and defect, shall be always less than the assumed limit of accuracy.

This is particularly easy to manage with a clock controlled by the action of a pendulum. By employing a series of weights the effect of which on the period of oscillation of the pendulum has been ascertained, and by suitably altering the weights upon the shelf of the pendulum from time to time as the diagram shows to be necessary, the movement of the clock, and consequently that of the telescope, can be made to agree with the apparent rate of movement of the star to any degree of precision required.

The length of exposure for which a uniform rate is permissible is determined in the following way from the curve drawn, as in fig. 1, for the declination of the star :—

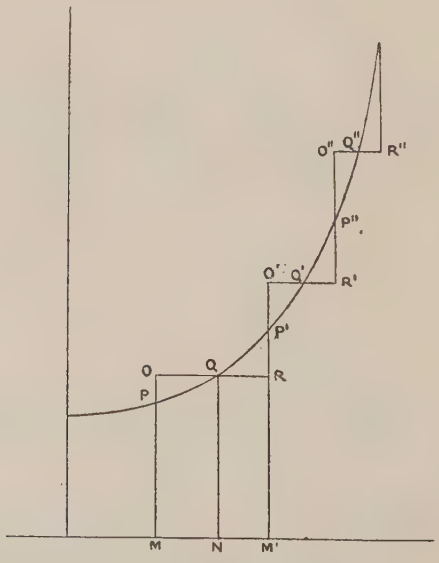


Fig. 2.

If r is the variable rate at which the star gains on the mean sidereal movement as given by formula (β), then the total gain in the interval $t'-t$ is $\int_t^{t'} r\,dt$.

If for the same interval of time we take a uniform rate r', the amount which the motion of the telescope gains on mean sidereal movement is $r'\,(t'-t)$, and the amount by which the telescope gains upon the star is represented by the difference between these two expressions. But the first is in fig. 2 represented by the area PP′M′M under the curve, while the second is the parallelogram ORM′M. Hence the displacement of the telescope with regard to the star at the end of the exposure is measured by the difference of the two areas OPQ and QRP′, and by taking a uniform rate represented by QN, corresponding to about the middle of the exposure, it can be used for the whole interval MM′ provided that neither area OPQ nor QRP′ exceeds the assumed limit of accuracy.

On the scale I have used, viz., 1^{mm} in the abscissæ to represent a rate of 1^s per day and 10^{mm} in the ordinates to represent an hour, this area, corresponding to a gain or loss of one-twentieth of a second, is 12 square millimetres, which at once enables us to judge for what length of exposure we may venture to use a uniform rate.

By drawing a zigzag line such that the approximately triangular areas contained between it and the curve shall never

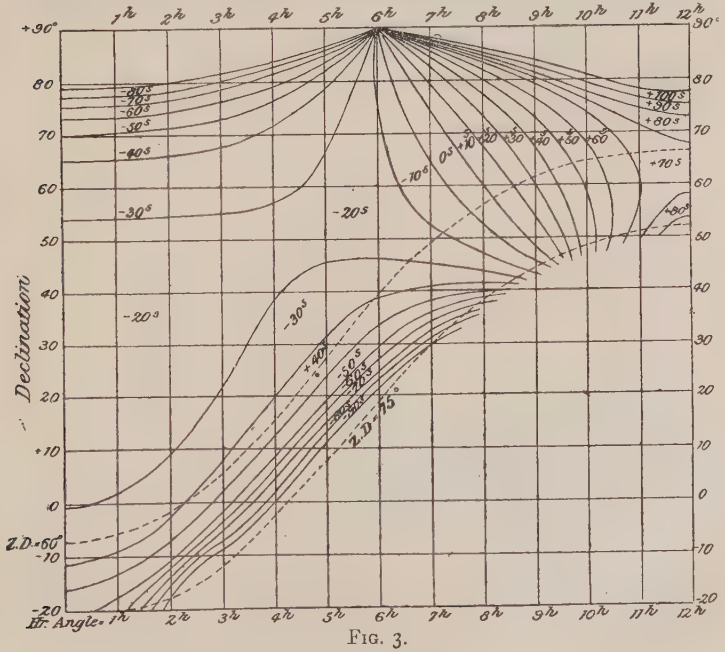


Fig. 3.

exceed 12 square millimetres, we get a series of uniform rates which will keep the pointing of the telescope constantly within one-twentieth of a second of the star.

When only short exposures of 5 or 10 minutes are necessary, as is generally the case with plates intended for accurate measurement, in which it is advisable to keep the star discs as small as possible, a still simpler method is available. By plotting down on squared paper the points on the sky for which the appropriate rates are -105^s, -95^s, . . . -5^s, $+5^s$, . . . $+95^s$, $+100^s$ a day, the abscissæ representing hour-angles and the ordinates representing declinations, we get a series of curves the spaces between which represent the regions of the sky for which the appropriate rates are -100^s, -90^s, . . . 0^s, . . . $+90^s$, $+100^s$ a day, and thus by a simple reference to this diagram, fig. 3, it is possible to read off the suitable clock-rate with sufficient accuracy.

This method I have found most convenient in practice for short exposures. I can turn the telescope with the greatest confidence from a star at its upper culmination, to follow which a star must lose at the rate of from 18 to 100 seconds or more a day, according to the declination, to another at its lower culmination apparently gaining at the rate of 70 or 80 seconds a day, and I find the telescope will follow both with equal accuracy.

The following table contains the rates suitable to each degree of declination, interpolated from the computed values referred to above, for the latitude of Dublin (53° 23′ 13″), and will serve to show through what a wide range the apparent angular velocity of a star varies. In this table + denotes a gaining, and − a losing, rate as compared with mean sidereal time.

LEEDS PHILOSOPHICAL AND LITERARY SOCIETY

TABLE.

Hour Angle.

Decl.	0^h	1^h	2^h	3^h	4^h	5^h	6^h	7^h	8^h	9^h	10^h	11^h	12^h
°	s	s	s	s	s	s	s	s	s	s	s	s	s
−20	−52·0	−61·2	−104·1	...	...	...	...	...	...	...	...	...	...
19	−49·4	−58·0	− 97·4	...	...	...	...	...	...	...	...	...	...
18	−46·9	−54·8	− 91·1	...	...	...	...	...	...	...	...	...	...
17	−44·6	−52·0	− 85·3	...	...	...	...	...	...	...	...	...	...
16	−42·5	−49·3	− 79·8	...	...	...	...	...	...	...	...	...	...
15	−40·5	−46·8	− 74·6	...	...	...	...	...	...	...	...	...	...
14	−38·6	−44·6	− 69·8	...	...	...	...	...	...	...	...	...	...
13	−36·9	−42·4	− 65·4	...	...	...	...	...	...	...	...	...	...
12	−35·4	−40·4	− 61·2	...	...	...	...	...	...	...	...	...	...
11	−33·9	−38·5	− 57 5	...	...	...	...	...	...	...	...	...	...
10	−32·7	−36·8	− 54·0	−110·1	...	...	...	...	...	...	...	...	...
9	−31·5	−35·3	− 50·9	−100·7	...	...	...	...	...	...	...	...	...
8	−30·4	−34·0	− 48·1	− 92·2	...	...	...	...	...	...	...	...	...
7	−29·4	−32·8	− 45·5	− 84·3	...	...	...	...	...	...	...	...	...
6	−28·6	−31·6	− 42·0	− 77·2	...	...	...	...	...	...	...	...	...
5	−27·8	−30·5	− 40·8	− 70·9	...	...	...	...	...	...	...	...	...
4	−27 0	−29·5	− 38·7	− 65·2	...	...	...	...	...	...	...	...	...
3	−26·2	−28·5	− 36·8	− 60 1	...	...	...	...	...	...	...	...	...
2	−25·6	−27·6	− 35·2	− 55·6	...	...	..	...	...	...	...	...	...

Decl.	0^h	1^h	2^h	3^h	4^h	5^h	6^h	7^h	8^h	9^h	10^h	11^h	12^h
°	s	s	s	s	s	s	s	s	s	s	s	s	s
−1	−24·9	−26·8	− 33·7	− 51·5	...	...	...	...	...	...	...	...	...
0	−24·3	−26·1	− 32·3	− 48·1	−94·0	...	...	...	...	...	...	...	...
+1	−23·8	−25·5	− 31·3	− 46·1	−88·0	...	...	...	...	...	...	...	...
2	−23·3	−25·0	− 30·4	− 44·1	−82·5	...	...	...	...	...	...	...	...
3	−22·9	−24·4	− 29·6	− 42·3	−77·3	...	...	...	...	...	...	...	...
4	−22·4	−23·9	− 28·8	− 40·7	−72·5	...	...	...	...	...	...	...	...
5	−22·0	−23·4	− 28·0	− 39·1	−68·2	...	...	...	...	...	...	...	...
6	−21·6	−23·0	− 27·3	− 37·6	−64·1	...	...	...	...	...	...	...	...
7	−21·3	−22·5	− 26·6	− 36·3	−60·4	...	...	...	...	...	...	...	...
8	−20·9	−22·1	− 26·0	− 35·1	−57·0	...	...	...	...	...	..	...	...
9	−20·6	−21·8	− 25·4	− 32·9	−53·9	...	...	...	...	...	...	...	...
10	−20·3	−21·4	− 24·9	− 32·8	−51·1	−104·2	...	...	...	...	...	.	...
11	−20·0	−21·1	− 24·5	− 31·9	−48·7	− 97·2	...	...	...	...	...	...	...
12	−19·8	−20·8	− 24·0	− 31·0	−46·8	− 90·8	...	...	...	...	...	...	...
13	−19·6	−20·5	− 23·6	− 30·2	−45·0	− 84·8	...	...	...	...	...	...	...
14	−19·4	−20·3	− 23·2	− 29·4	−43·2	− 79·4	...	...	...	. .	...	...	...
15	−19·2	−20·1	− 22·9	− 28·7	−41·6	− 74·3	...	...	...	...	...	...	...
16	−19·1	−19·9	− 22·6	− 28·1	−40·0	− 69·6	...	...	...	...	...	...	...
17	−18·9	−19·7	− 22·3	− 27·5	−38·6	− 65·4	...	...	...	...	...	...	...
18	−18·8	−19·5	− 22·0	− 26·9	−37·2	− 61·6	...	...	...	...	...	...	...
19	−18·7	−19·3	− 21·8	− 26·4	−36·0	− 58·0	...	...	...	...	...	...	...

Decl.	0^h	1^h	2^h	3^h	4^h	5^h	6^h	7^h	8^h	9^h	10^h	11^h	12^h
°	s	s	s	s	s	s	s	s	s	s	s	s	s
20	−18·6	−19·2	−21·7	−25·9	−34·9	−54·7	−110·0	...	...	...	...	...	...
21	−18·5	−19·1	−21·5	−25·5	−34·0	−52·2	−102·0	...	...	...	...	...	...
22	−18·5	−19·0	−21·3	−25·1	−33·1	−49·9	−94·5	...	...	...	...	...	...
23	−18·4	−18·9	−21·1	−24·8	−32·2	−47·8	−87·6	...	...	...	...	...	...
24	−18·4	−18·8	−21·0	−24·4	−31·4	−45·8	−81·2	...	...	...	...	...	...
25	−18·3	−18·8	−20·9	−24·1	−30·7	−43·9	−75·3	...	...	...	...	...	...
26	−18·3	−18·8	−20·8	−23·8	−30·0	−42·1	−69·9	...	...	...	...	...	...
27	−18·3	−18·7	−20·7	−23·6	−29·4	−40·5	−65·1	...	...	...	...	...	...
28	−18·3	−18·8	−20·6	−23·3	−28·8	−38·9	−60·7	...	...	...	...	...	...
29	−18·4	−18·8	−20·4	−23·1	−28·2	−37·5	−56·6	...	...	...	...	...	...
30	−18·4	−18·8	−20·2	−22·9	−27·7	−36·2	−52·9	−92·2	...	...	...	...	...
31	−18·4	−18·8	−20·2	−22·7	−27·3	−35·1	−49·9	−84·5	...	...	...	...	...
32	−18·5	−18·9	−20·3	−22·6	−26·9	−34·0	−47·4	−77·4	...	...	...	. .	...
33	−18·7	−18·9	−20·3	−22·4	−26·5	−33·1	−45·2	−70·8	...	...	...	...	...
34	−18·8	−19·0	−20·3	−22·3	−26·1	−32·2	−43·0	−64·8	...	...	...	...	...
35	−18·9	−19·2	−20·3	−22·2	−25·8	−31·3	−40·8	−59·2	...	...	...	...	...
36	−19·0	−19·3	−20·4	−22·2	−25·5	−30·5	−38·8	−54·1	...	...	...	...	...
37	−19·1	−19·4	−20·4	−22·2	−25·2	−29·7	−37·0	−49·4	...	...	. .	...	...
38	−19·2	−19·6	−20·4	−22·2	−24·9	−29·0	−35·3	−45·3	...	...	...	...	...
39	−19·4	−19·7	−20·5	−22·2	−24·7	−28·4	−33·8	−41·5	...	..	...	...	...
40	−19·6	−19·9	−20·7	−22·2	−24·5	−27·8	−32·3	−38·1	−43·9	−42·8	...	...	...

Decl.	0h	1h	2h	3h	4h	5h	6h	7h	8h	9h	10h	11h	12h
°	s	s	s	s	s	s	s	s	s	s	s	s	s
41	−19·8	−20·1	− 20·8	− 22·2	−24·3	− 27·3	− 31·1	−35·6	−39·1	−34·8	…	…	…
42	−20·1	−20·3	− 21·0	− 22·3	−24·1	− 26·9	− 29·9	−33·2	−34·5	−27·4	…	…	…
43	−20·5	−20·6	− 21·2	− 22·4	−24·0	− 26·4	− 28·9	−30·9	−30·4	−20·8	…	…	…
44	−20·8	−20·9	− 21·5	− 22·6	−23·9	− 26·0	− 27·9	−28·8	−26·5	−14·8	…	…	…
45	−21·1	−21·2	− 21·7	− 22·7	−23·8	− 25·6	− 26·9	−26·8	−23·0	− 9·5	…	…	…
46	−21·4	−21·5	− 22·0	− 22·8	−23·8	− 25·3	− 26·0	−25·1	−19·8	− 4·7	…	…	…
47	−21·7	−21·8	− 22·2	− 23·0	−23·8	− 24·9	− 25·1	−23·4	−16·9	− 0·4	…	…	…
48	−22·1	−22·1	− 22·5	− 23·2	−23·9	− 24·6	− 24·3	−21·8	−14·1	+ 3·4	…	..	…
49	−22·4	−22·5	− 22·8	− 23·4	−24·0	− 24·3	− 23·6	−20·3	−11·9	+ 6·7	…	…	…
50	−22·8	−22·9	− 23·2	− 23·6	−24·1	− 24·1	− 22·9	−18·9	− 9·4	+ 9·6	…	…	…
51	−23·3	−23·3	− 23·7	− 23·9	−24·2	− 23·9	− 22·3	−17·5	− 7·4	+11·8	+41·3	+ 73·9	+ 89·0
52	−23·8	−23·8	− 24·1	− 24·3	−24·4	− 23·7	− 21·7	−16·3	− 5·6	+13·6	+42·2	+ 72·6	+ 86·5
53	−24·3	−24·3	− 24·6	− 24·7	−24·5	− 23·5	− 21·1	−15·2	− 3·9	+15·3	+42·9	+ 71·4	+ 84·1
54	−24·9	−25·0	− 25·0	− 25·0	−24·7	− 23·4	− 20·5	−14·2	− 2·4	+16·8	+43·4	+ 70·2	+ 81·8
55	−25·6	−25·6	− 25·5	− 25·4	−25·0	− 23·3	− 20·0	−13·2	− 1·1	+18·3	+43·8	+ 69·0	+ 79·7
56	−26·3	−26·2	− 26·1	− 25·8	−25·2	− 23·2	− 19·6	−12·3	+ 0·2	+19·5	+44·4	+ 67·8	+ 77·8
57	−27·0	−26·9	− 26·8	− 26·4	−25·4	− 23·1	− 19·2	−11·4	+ 1·5	+20·7	+44·7	+ 66·8	+ 76·0
58	−27·7	−27·6	− 27·5	− 27·0	−25·7	− 23·1	− 18·8	−10·6	+ 2·6	+21·8	+45·0	+ 65·9	+ 74·4
59	−28·5	−28·4	− 28·2	− 27·6	−26·1	− 23·2	− 18·4	− 9·8	+ 3·7	+22·8	+45·3	+ 65·1	+ 73·1
60	−29·4	−29·3	− 28·9	− 28·1	−26·4	− 23·3	− 18·0	− 9·0	+ 4·8	+23·8	+45·7	+ 64·5	+ 72·0
61	−30·4	−30·3	− 29·8	− 28·8	−26·7	− 23·4	− 17·6	− 8·2	+ 5·9	+24·6	+46·1	+ 64·0	+ 71·0

Decl.	0h	1h	2h	3h	4h	5h	6h	7h	8h	9h	10h	11h	12h
°	s	s	s	s	s	s	s	s	s	s	s	s	s
62	−31·5	−31·3	− 30·9	− 29·7	−27·4	− 23·5	− 17·2	− 7·5	+ 6·8	+ 25·3	+46·5	+ 63·7	+ 70·4
63	−32·8	−32·6	− 32·0	− 30·6	−28·0	− 23·7	− 16·9	− 6·7	+ 7·9	+ 26·3	+47·1	+ 63·7	+ 70·1
64	−34·1	−33·9	− 33·1	− 31·5	−28·7	− 23·9	− 16·5	− 5·9	+ 9·0	+ 27·3	+47·9	+ 64·0	+ 70·1
65	−35·6	−35·4	− 34·3	− 32·5	−29·4	− 24·2	− 16·2	− 5·2	+ 10·1	+ 28·4	+48·9	+ 64·5	+ 70·5
66	−37·2	−36·9	− 35·7	− 33·6	−30·1	− 24·6	− 16·0	− 4·4	+ 11·3	+ 29·7	+50·2	+ 65·4	+ 71·0
67	−38·8	−38·5	− 37·2	− 34·8	−30·9	− 24·9	− 15·8	− 3·6	+ 12·6	+ 31·2	+51·6	+ 66·5	+ 72·0
68	−40·6	−40·2	− 38·8	− 36·1	−31·8	− 25·2	− 15·6	− 2·7	+ 14·0	+ 33·0	+53·2	+ 67·9	+ 73·3
69	−42·5	−42·0	− 40·5	− 37·5	−32·8	− 25·6	− 15·4	− 1·8	+ 15·5	+ 35·1	+55·0	+ 69·6	+ 74·9
70	−44·5	−44·0	− 42·3	− 39·0	−33·8	− 26·1	− 15·3	− 0·8	+ 17·3	+ 37·5	+57·0	+ 71·5	+ 76·9
71	−47·4	−46·9	− 44·9	− 41·2	−35·4	− 26·8	− 15·1	+ 0·2	+ 19·0	+ 39·9	+59·4	+ 73·9	+ 79·3
72	−50·9	−50·2	− 47·8	− 43·5	−37·1	− 27·6	− 14·9	+ 1·4	+ 21·0	+ 42·3	+62·1	+ 76·8	+ 82·2
73	−54·5	−53·8	− 51·2	− 46·3	−38·9	− 28·6	− 14·7	+ 2·7	+ 23·1	+ 45·0	+65·2	+ 80·0	+ 85·5
74	−58·7	−57·8	− 54·8	− 49·2	−41·1	− 29·7	− 14·5	+ 4·0	+ 25·5	+ 48·1	+68·7	+ 83·7	+ 89·2
75	−63·3	−62·2	− 58·8	− 52·6	−43·5	− 30·9	− 14·4	+ 5·4	+ 28·1	+ 51·5	+72·7	+ 87·8	+ 93·4
76	−68·4	−67·1	− 63·2	− 56·2	−46·1	− 32·1	− 14·3	+ 7·0	+ 30·9	+ 55·2	+77·1	+ 92·3	+ 98·1
77	−74·0	−72·5	− 68·1	− 60·2	−48·9	− 33·5	− 14·2	+ 8·6	+ 33·9	+ 59·4	+81·8	+ 97·5	+103·3
78	−80·2	−78·5	− 73·4	− 64·6	−52·0	− 35·1	− 14·1	+10·3	+ 37·2	+ 64·0	+87·0	+103·1	+109·0
79	−86·8	−84·9	− 79·3	− 69·4	−55·3	− 36·8	− 14·0	+12·3	+ 40·8	+ 68·8	+92·8	+109·2	+115·2
80	−94·0	−91·9	− 85·5	− 74·6	−59·0	− 38·7	− 13·9	+14·5	+ 44·8	+ 74·2	+99·1	+115·9	+121·9

I may add that it is often a convenience to know at what rate the refraction in declination varies during an exposure. This may be computed in a similar manner. From the second of equations (α) we find

$$\Delta\delta = \Delta\zeta \cos\eta = \beta \tan\zeta \cos\eta,$$

or

$$\Delta\delta = \beta \cdot \frac{\cos\delta \sin\phi - \sin\delta \cos\phi \cos h}{\sin\delta \sin\phi + \cos\delta \cos\phi \cos h}.$$

And since the apparent declination (δ') is equal to $\delta + \Delta\delta$, we have

$$\frac{d\delta'}{d\theta'} = \frac{d\Delta\delta}{d\theta} = \beta \cdot \frac{\sin\phi \cos\phi \sin h}{\{\sin\delta \sin\phi + \cos\delta \cos\phi \cos h\}^2} \quad \ldots\ldots (\gamma)$$

Hence we see that the apparent declination is always increasing on the west and always diminishing on the east of the meridian, as is otherwise obvious.

With the same substitution as before, we can write this expression in the form

$$\frac{d\delta'}{d\theta'} = \beta \frac{\cos\phi \cdot \cos v}{\sin^2 n \sin^2(m+\delta)} \quad \ldots\ldots\ldots (\delta)$$

which is very convenient for computation.

This also varies within limits, which, in comparison with the accuracy of which measurements of stellar photographs are susceptible, may be considered wide. It is of course zero on the meridian, while at a zenith distance of 60° (at which it is possible to get first-rate photographs for measurement) it may amount to as much as 0″·5 per minute.

Dunsink Observatory:
1896 *December* 1.

Observations of the Leonids on 1896 *November* 13 *and* 14.

By Prof. Arthur A. Rambaut, M.A., D.Sc.

Although our observations this year at Dublin of the meteors belonging to the *Leonid* stream fall far short of what we hoped for, and in point of accuracy and completeness leave a good deal still to be desired, yet in view of the unfavourable character of the weather, which prevented observations at so many other stations, the results we obtained may possibly be of value, and ought at least to be put on record.

Cloudy weather prevented observations on the night of November 12.

On the 13th my assistant, Mr. Charles Martin, commenced his watch at $12^h\ 55^m$ G.M.T. At that time it was very cloudy in the east, with a film of thin clouds all over the sky, which began to clear up shortly afterwards, and by $13^h\ 55^m$ had quite disappeared. The first meteor was recorded at $14^h\ 16^m$, and was followed by others as exhibited in the following table :—

TABLE I.

Observation of Meteors, 1896 *November* 13.

No.	Time first seen G.M.T. d	h	m	Point first seen at.	Mag.	Colour.	Notes.
1	13	14	16	π Leonis	2	Yellow	
2		14	25	o „	1	White	
3		14	45	Orion	1	Red	
4		14	47	λ Leonis	4	White	
5		14	49	κ „	4	„	
6		15	0	ζ „	3	„	
7		15	1	o „	4	„	
8		15	1	Orion—Leo	1	„	
9		15	2	ζ Leonis	1	Red	Seen for 14°. Drifted N.E.
10		15	13	Between γ and ζ Leonis	4	White	
11		15	16	„ ν and o Leonis	4	Yellow	
12		15	20	o Leonis	0	White	
13		15	31	ρ „	3	„	
14		15	40	ϵ Ursæ Majoris	−1	Yellow	Came from ϵ Ursæ Maj. and lasted till it reached Regulus.
15		15	44	θ Leonis	2	White	
16		15	47	κ „	3	„	
17		15	51	Between α Leonis and Jupiter	2	„	
18		15	56	20 Leonis	3	„	
19		16	0	θ „	4	Red	
20		16	3	λ „	2	Bright red	
21		16	25	γ „	−2	White	
22		16	40	η „	1	Yellow	

$12^h\ 55^m$, cloudy in E, clearing up, though very thin clouds all over the sky.
$13^h\ 55^m$, quite clear.
$16^h\ 55^m$, clouded up.
Moon set about $13^h\ 40^m$. Age at noon Nov. 13, $8^d\ 5^h$.

The last meteor was noticed at $16^h\ 40^m$ when the clouds

began to gather once more, and by $16^h\ 55^m$ the sky was so hopelessly overcast that the watch was discontinued.

The tracks of these meteors were plotted down by Mr. Martin at the time upon a map of the constellation *Leo* prepared before hand, and the results of his observations are reproduced in fig. 1.

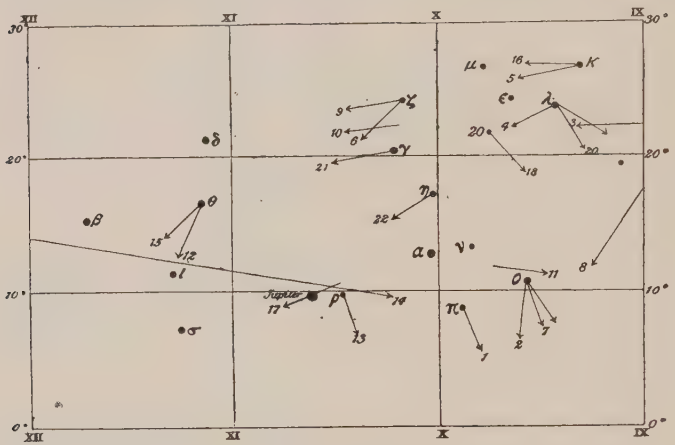


FIG. 1.—Meteor Tracks, 1896 November 13.

On the following day I attached a camera to the tube of our photographic equatorial in the hope of getting automatic records of some of the brighter meteor-trails. The lens was a rapid-rectilinear of $1\frac{1}{4}$ inch diameter (of which the full aperture was used), and about $8\frac{1}{2}$ inches equivalent focus. But although I employed Cadett & Neale's Lightning plates, $7\frac{1}{2}$ by 5 inches in size, which thus covered a region of about $50° \times 33°$ upon the sky, and although several of the meteors crossed the field of view covered by the lens, not a single one of them was bright enough to leave a trace upon the photograph.

It will at once be objected that the lens was too small, and, of course, I did not venture to hope that I should succeed in getting photographs of all the meteors which we saw; but I was disappointed to find that even the brighter ones, which appeared of about the first or second stellar magnitude, left no trace upon the plate.

My experiment, therefore, although the result is of a negative character, may possibly be of some use in affording a lower limit to the aperture of lens which can be used for this purpose with any prospect of success, and if the fainter meteors are looked for the lens will have to be of much larger dimensions.

Unfortunately this photographic experiment was not only unsuccessful, but was positively detrimental to the completeness of our watch on this night; for on account of the temporary and make-shift character of the apparatus I found it necessary to

call Mr. Martin in to help me in removing and replacing the cap.

His own observations, which he conducted as on the previous night, were in this way three times interrupted, but a continuous watch was maintained by him

	h	m		h	m	
from	13	40	to	13	50	G.M.T.
„	14	19	„	15	19	„
„	15	32	„	16	31	„
„	16	53	„	17	49	„

and his results are given in the following table :—

TABLE II.

Observation of Meteors, 1896 *November* 14.

No.	Time first seen (G.M.T.) d	h	m	Point first seen at.	Mag.	Colour.	Notes.
1	14	13	46	Between ζ and μ Leonis	1	White	Seen for 4^s.
2		14	26	Between Jupiter and θ Leonis	2	„	
3		14	28	β Leonis	2	„	
4		14	32	Between μ and ϵ Leonis	1	Yellow	Seen for 5^s.
5		14	42	o Leonis	4	White	
6		15	3	„	4	„	
7		15	3	θ „	4	„	
8		15	19	η „	6	Red	
9		15	40	δ „	4	White	
10		15	41	o „	3	Red	
11		15	41	θ „	2	White	Seen for 4^s.
12		15	47	β „	4	„	
13		15	52	Between Jupiter and γ Leonis	2	„	
14		16	0	δ Leonis	5	Yellow	
15		16	3	o „	4	„	
16		16	6	γ „	2	„	
17		16	7	ϵ „	3	White	
18		16	10	Between Jupiter and θ Leonis	4	Yellow	
19		16	11	ζ Leonis	1–2	White	$1\frac{1}{2}^\circ$ long.
20		16	11	β „	2	„	
21		16	15	α Cancri (?)	4	„	
22		16	25	Jupiter	1	„	
23		17	1	ρ Leonis	2	„	
24		17	23	ν „	4	„	
25		17	47	20 „	4	„	

Moon set about 14^h 49^m, age at noon November 14 9^d 5^h.

The tracks as plotted down by him are represented in fig. 2.

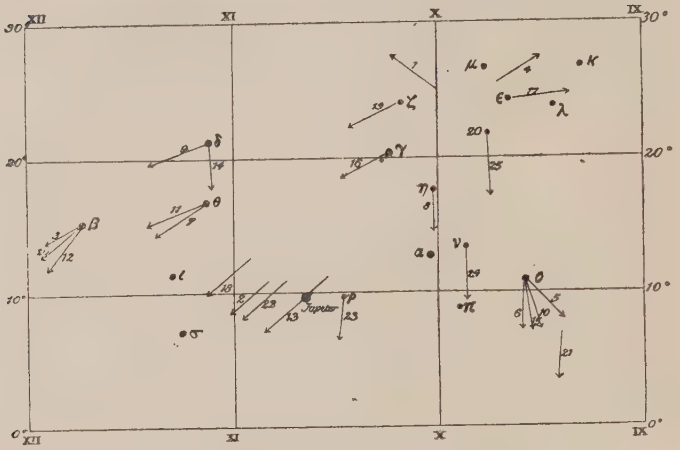


FIG. 2.—Meteor Tracks, 1896 November 14.

From the observations as given above we deduce the following table, giving the number of meteors seen in each successive period of ten minutes on the two mornings :—

TABLE III.

G.M.T. h m	No. of meteors seen on Nov. 13.	No. of meteors seen on Nov. 14.	G.M.T. h m	No. of meteors seen on Nov. 13.	No. of meteors seen on Nov. 14.
13 40			50		
	0	1		2	1
50			16 0		
	0	[0]		2	3
14 0			10		
	0	[0]		0	4
10			20		
	1	[0]		1	1
20			30		
	1	1		0	[0]
30			40		
	0	1		1	[0]
40			50		
	2	1		...	0
50			17 0		
	0	0		...	1
15 0			10		
	3	2		...	0
10			20		
	2	1		...	1
20			30		
	1	[0]		...	0
30			40		
	1	0		...	1
40			50		
	2	4			

At first sight these observations seem to point to an increase in the number of meteors on both mornings in the interval between $14^h\ 30^m$ and $16^h\ 30^m$, which, if real, would be difficult to account for. I think, however, the apparent falling off in point of numbers towards the end of the first night's watch is possibly due to a gradual coming on of clouds, which is very likely to have preceded total obscuration, although Mr. Martin has not recorded it; and on the second night the light of the Moon, which set about $14^h\ 49^m$, and the small altitude of the constellation *Leo* at first may have conspired to render some of the meteors invisible. The increase in numbers at $14^h\ 40^m$ on November 13 and the falling off after $16^h\ 30^m$ on November 14 seem to be real, as the sky was clear at both times; and, I think, a more probable deduction from these observations, if, indeed, they are not too meagre to afford a basis for any such deduction, is that the densest part of the swarm which we passed through this year was encountered during the interval between our two watches—perhaps during the daylight hours of Saturday, 14th.

From the tracks as laid down by Mr. Martin, it would appear that the meteor trails of November 14 diverge much more nearly from a point than do those of the 13th; and although I would not rely too much on the absolute accuracy of any track—for I think the number of trails which are drawn as issuing from stars would show that the proximity of a bright star has biassed the observer's estimate of the position of the meteor's path—yet I am inclined to think that the greater divergence of the trails recorded on November 14 is not a mere chance result of errors of observation, but points to a real difference in the character of the paths on the two occasions.

In this connection I may remark, although, indeed, the fact might be used as an argument against this conclusion, that the three meteors which Mr. Martin notes as having lasted for several seconds, thus affording him a better opportunity of determining their paths, seemed to diverge almost exactly from the radiant point, as determined by Mr. Denning and given in the *Admiralty Manual* for 1886.

The following letters were read by Dr. Johnstone Stoney at the meeting of the Society on 1896 December 11 :—

Quinta Cuibem, Caminho do Til, Funchal, Madeira :
1896 November 27.

Dear Sir,—In accordance with the request contained in the circular which you issued through the Royal Astronomical Society last July, I kept a watch upon the *Leonids* on the morning of the 14th inst., and immediately sent my observations to the journal of the British Astronomical Association, thinking that they would be in time for the November number of that paper, in which I expected you would probably see them. I find, however, that they were not in time for that number of the journal, and so I now venture to send them to yourself in case they may be of some use.

As I have not had experience in the charting of meteors, I did not attempt to map them, especially since you have pointed out in the November number of the *Observatory* that photography is the only satisfactory method for determining the radiant-point. I have no means of photographing the meteors here, and therefore confined myself to counting them and noting the times of their appearance, together with the directions of their flight (roughly), since it might perhaps assist in identifying a particular meteor. I kept an almost constant watch from G.M.T. $2^h\ 8^m$ until $6^h\ 10^m$, and the inclosed list contains all the undoubted *Leonids* which I saw, although of twenty-seven other meteors which I noted, several, perhaps four or five, were possible *Leonids*. On account of trees, I had to observe from an upper (open) window of a house, facing south-east, so that I may have missed some meteors which possibly appeared towards the north or north-west ; but I kept a good look-out up to the zenith, and from the north-east round by south to south-west.

Altogether I saw twenty-nine *Leonids*, as given in the list, and the curve given on the back of the latter shows their distribution in periods of half an hour each. There was a rapid increase in their numbers from 4 o'clock until 5.30.

The Earth does not appear to have met with the beginning of the meteor-stream during the period of my watching, but perhaps observers further west have been better rewarded.

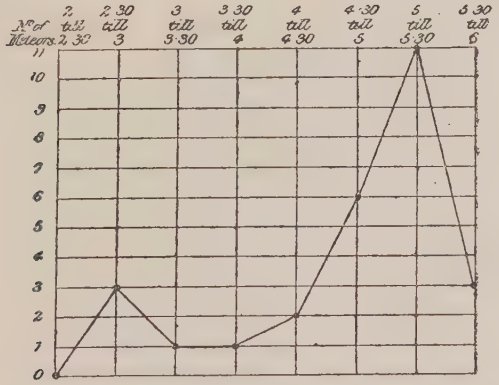
Trusting that my notes may be of some use to you,
I am, yours very sincerely,
Wm. Anderson.

G. J. Stoney, Esq., D Sc., F.R.S.

Leonids seen at Madeira on the morning of 1896 November 14.

Greenwich mean times of appearances given. No meteors appeared between $2^h\ 8^m$ A.M. and $2^h\ 38^m$.

Time.	No. of Meteors.	Direction.	Time.	No. of Meteors.	Direction.
2.38 A.M.	1	Line of sight.	5.4 A.M.	2	S.W.
2.40	1	S.W.	5.6	1	S.W.
2.51	1	S.	5.10	1	N.E.
3.9	1	S.W.	5.14	1	N.E.
3.50	1	S.	5.17	1	N.E.
4.8	1	E.	5.18	1	E.
4.23	1	S.E.	5.20	1	S.E.
4.47	1	E.	5.25	1	S.W.
4.51	1	S.	5.30	1	E.
4.54	1	S.E.	5.44	1	S.W.
4 55	1	S.	5.45	1	N.E.
4.57	1	E.	5.53	1	S.E.
4 59	1	S.W.	6.2	1	S.E.
5.3	1	S.W.	6.6	1	E.



Distribution in time of the foregoing *Leonids*.

c/o Kilburn & Co., Calcutta:
1896 November 18.

Dear Sir,—Re *Leonids*. On November 14 I watched this shower from the time of rising till 16^h Calcutta Local Time (4 A.M. Sunday). Up till 14^h I was only keeping a casual look-out, as I was at my telescope, but till then there were very few meteors visible, and only one bright one from *Leo*.

Between 14^h 30^m and 16^h there were altogether twenty-seven meteors that I saw. Of these twelve came from the *Leonid* radiant, which was as near as I could judge $21° \times 152°$.

Nine of these twelve were about -1 magnitude, and they were, with exception of two, brilliant yellow with streaks lasting some time. The two exceptions were the brightest of all and

brilliant purple-white, like an electric arc. These two appeared at $15^h\ 15^m$ and $15^h\ 18^m$.

They came from the direction of the radiant, but being parallel I could not tell whether they belonged to the shower.

Many of the other meteors noticed came from a point in *Leo*, but they were not so bright, and had not lasting streaks.

Yours faithfully,

J. Willoughby Meares.

Ephemeris of the Leonids; with Introductory Remarks by G. Johnstone Stoney, M.A., D.Sc., F.R.S.

The *Leonids* are extended in the form of a stream along their orbit, the dense part of the stream being about 100,000 miles across, and of such length that it takes between one and two years—probably nearly two years—to pass each point. It is at present advancing towards perihelion, and is therefore lengthening out.

The following Ephemeris is of that situation in the stream through which the Earth passed in 1866. It has been computed from Adams's "Elements" (*Monthly Notices* of the Royal Astronomical Society for 1867 April, p. 250) by applying to the orbit the mean advance in longitude of its node, but without further taking into account the perturbations which *Jupiter*, *Saturn*, and *Uranus* have impressed upon the orbit since 1866. It was judged to be useless to attempt greater accuracy, since Professor Adams's elements are themselves uncertain within considerable limits, owing to the very discordant determinations of the radiant point which he had to make the starting point of his calculations. In fact the differences between the individual determinations and their mean ranged up to as much as a whole degree in both Right Ascension and Declination.

Nevertheless, it is hoped that the Ephemeris will be sufficient for the use for which it is intended—viz. to enable astronomers to make their first attempt next spring to obtain a photograph of the meteors while at a distance in the open sky. It will be seen from the Ephemeris that next spring they will be nearly as far off as *Saturn*, whose crape ring (formed of bodies separated like the meteors at a distance from one another) is visible at the ansæ, under favourable circumstances, in observations which are mere eye observations, and notwithstanding the close proximity of bright bodies on all sides. It follows that a very much fainter object might be successfully photographed in a dark part of the sky. Any computation, however, which we can make leads to the conclusion that the meteor stream is so excessively faint that we must not be discouraged if our best efforts on this occasion are unsuccessful. It will in that case be desirable to renew the attempt in the spring of 1898, when the stream will have got nearer to the Sun, and will have become brighter under his beams.

Next spring the stream will be drawn out to an apparent length of at least 5°—possibly 8°—so that if it can be photographed at all it will present the appearance of a streak the whole way across the photographic plate, and about 20′ wide. The uncertainty of the data for the Ephemeris makes it desirable that a full field on each side of that track which is indicated by the Ephemeris shall be explored.

The Ephemeris has been computed by Mr. Wright, of the *Nautical Almanac* Office, under Dr. Downing's special direction, which he most kindly gave; and the cost of making the calculations has been defrayed out of the Donation Fund of the Royal Society.

It is probable that no observations can be made next January, owing to the low position of the swarm in the eastern sky and the approach of dawn, nor in the middles of the succeeding months on account of moonlight, but in the early and late portions of February, March, and April everything will be favourable. The position of the swarm will become more convenient for observation as the season advances, until in April the best conditions will prevail. Soon after that twilight will be troublesome.

Approximate Ephemeris of the Leonids for the first four months of 1897.

Greenwich Midnight.	Right Ascension.	Decl.	Log. of Dist. from Earth.	Greenwich Midnight.	Right Ascension.	Decl.	Log. of Dist. from Earth.
1897.	h m s	° ′		1897.	h m s	° ′	
Jan. 1	14 28 19	S 8 39	0·9976	Jan. 22	14 30 1	S 8 29	0·9768
2	14 28 28	8 39	0·9967	23	14 30 1	8 28	0·9757
3	14 28 36	8 39	0·9957	24	14 30 1	8 27	0·9747
4	14 28 44	8 39	0·9948	25	14 30 1	8 26	0·9736
5	14 28 52	8 39	0·9938	26	14 30 0	8 25	0·9726
6	14 28 59	8 38	0·9929	27	14 29 59	8 24	0·9715
7	14 29 5	8 38	0·9919	28	14 29 57	8 23	0·9704
8	14 29 12	8 38	0·9909	29	14 29 55	8 22	0·9694
9	14 29 18	8 37	0·9900	30	14 29 52	8 20	0·9683
10	14 29 24	8 37	0·9890	31	14 29 50	8 19	0·9672
11	14 29 29	8 37	0·9880	Feb. 1	14 29 47	8 18	0·9662
12	14 29 34	8 36	0·9870	2	14 29 43	8 17	0·9651
13	14 29 38	8 36	0·9860	3	14 29 38	8 15	0·9640
14	14 29 42	8 35	0·9850	4	14 29 33	8 14	0·9630
15	14 29 46	8 34	0·9840	5	14 29 27	8 12	0·9619
16	14 29 49	8 34	0·9830	6	14 29 22	8 11	0·9608
17	14 29 52	8 33	0·9820	7	14 29 16	8 9	0·9598
18	14 29 54	8 32	0·9809	8	14 29 9	8 8	0·9587
19	14 29 56	8 32	0·9799	9	14 29 2	8 6	0·9576
20	14 29 58	8 31	0·9789	10	14 28 54	8 4	0·9565
21	14 30 0	8 30	0·9778	11	14 28 46	8 3	0·9555

Greenwich Midnight.	Right Ascension.	Decl.	Log. of Dist. from Earth.	Greenwich Midnight.	Right Ascension.	Decl.	Log. of Dist. from Earth.
1897.	h m s	° ′		1897.	h m s	° ′	
Feb. 12	14 28 38	S 8 1	0·9544	Mar. 24	14 16 48	S 6 22	0·9164
13	14 28 29	7 59	0·9533	25	14 16 22	6 19	0·9157
14	14 28 19	7 58	0·9523	26	14 15 55	6 16	0·9150
15	14 28 9	7 56	0·9512	27	14 15 28	6 12	0·9143
16	14 27 59	7 54	0·9501	28	14 15 1	6 9	0·9136
17	14 27 48	7 52	0·9491	29	14 14 33	6 6	0·9129
18	14 27 37	7 50	0·9480	30	14 14 5	6 3	0·9122
19	14 27 25	7 48	0·9470	31	14 13 37	6 0	0·9115
20	14 27 13	7 46	0·9459	Apr. 1	14 13 9	5 57	0·9109
21	14 27 0	7 44	0·9449	2	14 12 41	5 53	0·9103
22	14 26 47	7 41	0·9438	3	14 12 12	5 50	0·9097
23	14 26 34	7 39	0·9428	4	14 11 43	5 47	0·9091
24	14 26 20	7 37	0·9418	5	14 11 14	5 44	0·9085
25	14 26 5	7 35	0·9408	6	14 10 45	5 40	0·9079
26	14 25 50	7 33	0·9398	7	14 10 15	5 37	0·9074
27	14 25 35	7 30	0·9388	8	14 9 45	5 34	0·9069
28	14 25 19	7 28	0·9378	9	14 9 15	5 31	0·9064
Mar. 1	14 25 3	7 25	0·9368	10	14 8 45	5 27	0·9059
2	14 24 46	7 23	0·9358	11	14 8 15	5 24	0·9054
3	14 24 28	7 21	0·9348	12	14 7 45	5 21	0·9050
4	14 24 10	7 18	0·9338	13	14 7 14	5 18	0·9045
5	14 23 52	7 16	0·9329	14	14 6 43	5 14	0·9041
6	14 23 33	7 13	0·9319	15	14 6 12	5 11	0·9037
7	14 23 14	7 10	0·9310	16	14 5 41	5 8	0·9033
8	14 22 55	7 8	0·9300	17	14 5 10	5 5	0·9029
9	14 22 35	7 5	0·9291	18	14 4 39	5 1	0·9026
10	14 22 15	7 3	0·9282	19	14 4 7	4 58	0·9023
11	14 21 54	7 0	0·9273	20	14 3 36	4 55	0·9020
12	14 21 33	6 57	0·9264	21	14 3 4	4 52	0·9017
13	14 21 11	6 54	0·9255	22	14 2 32	4 48	0·9014
14	14 20 49	6 51	0·9246	23	14 2 1	4 45	0·9011
15	14 20 27	6 49	0·9237	24	14 1 30	4 42	0·9009
16	14 20 4	6 46	0·9229	25	14 0 58	4 39	0·9007
17	14 19 41	6 43	0·9220	26	14 0 27	4 36	0·9005
18	14 19 17	6 40	0·9212	27	13 59 56	4 33	0·9003
19	14 18 53	6 37	0·9203	28	13 59 24	4 29	0·9001
20	14 18 29	6 34	0·9195	29	13 58 53	4 26	0·9000
21	14 18 4	6 31	0·9187	30	13 58 22	4 23	0·8998
22	14 17 39	6 28	0·9179	May 1	13 57 50	4 20	0·8997
23	14 17 14	6 25	0·9172				

Observations of the Leonid Meteors, 1896, *at the Oxford University Observatory.*

(*Communicated by H. H. Turner, M.A., B.Sc., Director.*)

On November 13 the night was thickly overcast with fog, and no meteors were seen.

On November 14 a watch was kept by Mr. F. A. Bellamy and Mr. F. C. H. Carpenter from 9^h till 16^h.

Mr. Carpenter commenced to watch at $11^h\ 15^m$ for any meteors that might appear about the constellation *Leo*, with instructions to note the number counted every quarter of an hour, and to locate any specially bright ones. None were seen from $11^h\ 15^m$ to 12^h, individual meteors were seen at $12^h\ 4^m$, $13^h\ 7^m$, $13^h\ 13^m$, and $13^h\ 58^m$; at $14^h\ 15^m$ the sky became overcast and remained so till $15^h\ 30^m$. Cloud was frequent throughout the period of watch.

Preparations were made by Mr. F. A. Bellamy to photograph the radiant point. Two cameras were fixed to the telescope in the De la Rue dome, and one to the Astrographic telescope; a plate was also exposed in the latter telescope; both telescopes were pointed at R.A. 10^h and Dec. $+20°$. No meteor tracks were found on the plates.

Cloudy weather with drizzling rain prevented any attempt being made to photograph the *Andromedes* on November 27.

The Aurora of 1896 *March* 4. By T. W. Backhouse.

The aurora of March 4 was observed here, though not by myself before $10^h\ 57^m$. A ray, probably the same as that noted by Mr. Goatcher at Cambridge, was seen by my secretary as a conspicuous feature, being at $8^h\ 27^m$ G.M.T. almost vertically under the *Pleiades*, pointing to those stars, and reaching, bright, to half, thence gradually fainter to five-sixths their altitude; it had moved slightly and slowly southwards during the previous five minutes. There is uncertainty as to whether this feature was sufficiently inclined to the vertical as seen here to be a true and perfect auroral ray; while at Cambridge the inclination was too great. It is not professed that the inclination is accurately given at either place; but unless there is considerable error in the descriptions it would appear that the phenomenon was a bundle of rays rather than a single one, and that the lower portion was further east than the upper. It is clear that a true auroral ray was seen later in the evening by other observers, according to

the records in the *Monthly Notices* of March last. Anyone who is familiar with the ordinary type of aurora with streamers cannot fail to recognise in most of the accounts contained in that number of the *Notices*, and the drawing by Sir W. J. Herschel on p. 334, a very good description of an auroral display. No doubt Sir W. J. Herschel and others saw the zodiacal light as well, and it was merely a coincidence that the two phenomena were superposed.

Observations of the ray seen here were made at several other places, and one made at York by Mr. J. E. Clark was sufficiently exact for him to use in conjunction with those at Sunderland and Cambridge to calculate the height. He finds that at 8.30 P.M. it was 200 miles above Galway Bay at the top, and 40 miles or less at its base, above a point a quarter of the distance from Louth to Drogheda. With these positions it could not be a simple ray ; but if we assume that it was one, and that there was error in the descriptions, and take the mean position, it would still leave the middle of the ray at an altitude of about 120 miles, while the height of the apex would be lowered, and that of the base increased.

Observations of Minor Planets at Windsor, New South Wales.

By John Tebbutt.

The accompanying observations of minor planets during 1896 were made with the filar micrometer on the 8-inch equatorial and in an illuminated field. The differential observations are corrected for refraction, and a small error in the perpendicularity of the micrometer threads. The distance threads of the micrometer are so fine and the planet *Undina* was so faint that considerable difficulty was experienced in this case. On comparing the resulting places of *Calliope* with an approximate ephemeris kindly furnished by Dr. Bauschinger, of Berlin, I found there was a fair agreement except in the case of September 21, 22, 23, when the places depend on star No. 1. The only authority I could find for this star was Arg.-Oeltzen, in which catalogue it is given as No. 300. I was led to suspect that the tabular N.P.D. of this star was about a minute too great, and I accordingly made six comparisons of the star with the clock star β *Ceti* on October 16, the result of which completely confirmed my suspicions. I have therefore adopted the mean place as derived from the equatorial comparisons. *Sappho* was brighter than I expected to find it. The opposition magnitude given in the *Berliner Astronomisches Jahrbuch* for 1898 is 9·3, whereas I regarded it as fully equal to 8·5. I will add that the quantities $p\Delta$ have been computed with an assumed value of the solar parallax $=8''{\cdot}85$.

Date.	Windsor Mean Time.	Planet−Star. Δ R.A.	Δ N.P.D.	No. of Comps.	Planets App. R.A.	Log. $p\Delta$	Planet's App. N.P.D.	Log. $p\Delta$.	Reduction to App. Place R.A.	Reduction to App. Place N.P.D.	Comp. Star.
				(6) *Hebe.*							
1896.	h m s	m s	′ ″		h m s		° ′ ″		s	″	
May 17	9 52 22	+0 24·34	−10 14·1	20	17 0 37·86	9·585*n*	90 34 56·9	0·683	+2·91	+14 5	1
18	9 56 9	−0 25·22	−13 26·3	20	16 59 48·31	9·571*n*	90 31 44·6	0·684	+2·92	+14·4	1
30	9 15 17	+1 7·79	+18 24·3	15	16 48 55·24	9·541*n*	90 7 15·5	0·687	+3·11	+13·5	2
June 1	8 42 31	−0 47·24	+16 59·9	7	16 47 0·23	9·581*n*	90 5 50·8	0·687	+3·13	+13·2	2
5	9 16 4	−4 43·59	+16 42·2	10	16 43 3·93	9·475*n*	90 5 32·6	0·687	+3·18	+12·7	2
5	9 16 4	−1 0·48	+11 35·9	10	16 43 3·95	9·475*n*	90 5 30·5	0·687	+3·17	+12·9	3
10	9 39 25	−1 20·68	+ 1 1·5	10	16 38 11·29	9·324*n*	90 9 58·5	0·686	+3·22	+12·5	4
10	9 39 25	−2 58·14	+ 0 21·7	10	16 38 11·09	9·324*n*	90 9 59·6	0·686	+3·22	+12·4	5
11	8 26 43	−2 15·42	+ 2 30·4	15	16 37 16·56	9·521*n*	90 11 27·3	0·686	+3·23	+12·4	4
11	8 26 43	−3 52·81	+ 1 50·6	15	16 37 16·43	9·521*n*	90 11 28·4	0·686	+3·23	+12·3	5
13	8 40 54	+3 17·75	+ 2 58·7	15	16 35 22·33	9·465*n*	90 15 11·5	0·685	+3·23	+12·4	6
14	8 35 5	+2 21·91	+ 5 10·7	15	16 34 26·50	9·467*n*	90 17 23·4	0·685	+3·24	+12·3	6
15	8 53 51	+1 25·65	+ 7 37·6	15	16 33 30·24	9·400*n*	90 19 50·2	0·684	+3·24	+12·2	6
16	7 40 6	+0 33·70	+10 6·3	20	16 32 38·30	9·563*n*	90 22 18·8	0·685	+3·25	+12·1	6
				(11) *Parthenope.*							
Apr. 11	9 55 2	+4 4·40	+12 20·5	12	14 47 58·97	9·599*n*	98 16 53·3	0·621	+2·52	+18·7	1
11	9 55 2	+0 36·39	...	12	14 47 59·27	9·599*n*	...	...	+2·52	...	2
12	9 56 49	+3 20·26	+ 7 20·6	15	14 47 14·85	9·590*n*	98 11 53·4	0·620	+2·54	+18·7	1
12	9 56 49	−0 7·71	...	15	14 47 15·19	9·590*n*	...	...	+2·54	...	2

Date.	Windsor Mean Time.	Planet−Star. Δ R.A.	Planet−Star. Δ N.P.D.	No. of Comps.	Planet's App. R.A.	Log. $p\Delta$.	Planet's App. N.P.D.	Log. $p\Delta$.	Reduction to App. Place R.A.	Reduction to App. Place N.P.D.	Comp. Star.
1896.	h m s	m s	′ ″		h m s		° ′ ″		s	″	
Apr. 13	10 13 42	+2 34·59	+ 2 17·5	11	14 46 29·20	9·553*n*	98 6 50·3	0·613	+2·56	+18·7	1
13	10 13 42	−0 53·48	...	11	14 46 29·43	9·553*n*	...	...	+2·55	...	2
14	10 6 21	+1 48·46	− 2 44·0	10	14 45 43·08	9·558*n*	98 1 48·8	0·615	+2·57	+18·7	1
14	10 6 21	−3 14·96	+ 3 40·1	10	14 45 43·13	9·558*n*	98 1 49·9	0·615	+2·57	+18·7	3
15	9 35 44	+1 1·21	− 7 41·0	10	14 44 56·85	9·599*n*	97 56 51·8	0·625	+2·59	+18·7	1
15	9 35 44	−4 1·28	− 1 15·6	10	14 44 56·82	9·599*n*	97 56 54·2	0·625	+2·58	+18·7	3
17	9 56 8	+4 33·25	− 2 22·1	7	14 43 18·69	9·551*n*	97 46 43·0	0·616	+2·62	+18·8	4
17	9 56 8	−5 39·48	...	7	14 43 18·65	9·551*n*	...	...	+2·61	...	3
18	9 50 28	+3 43·28	− 7 23·5	10	14 42 28·73	9·552*n*	97 41 41·6	0·617	+2·63	+18·8	4
18	9 50 28	−6 29·43	...	10	14 42 28·71	9·552*n*	...	...	+2·62	...	3
19	10 22 8	+2 51·15	−12 33·6	10	14 41 36·61	9·473*n*	97 36 31·5	0·607	+2·64	+18·8	4
23	10 14 26	−2 38·76	− 5 12·7	10	14 38 5·71	9·442*n*	97 16 36·1	0·608	+2·69	+18·8	5
24	9 22 39	−3 30·95	− 9 56·3	10	14 37 13·53	9·550*n*	97 11 52·5	0·622	+2·70	+18·8	5
30	10 3 33	−1 28·14	+ 0 29·9	14	14 31 40·27	9·368*n*	96 43 25·7	0·610	+2·76	+18·8	6
May 1	9 13 14	−2 21·85	− 3 48·6	16	14 30 46·57	9·498*n*	96 39 7·2	0·621	+2·77	+18·8	6
3	8 52 28	+1 1·52	+ 1 33·1	9	14 28 55·71	9·523*n*	96 30 29·9	0·626	+2·78	+18·8	7
3	8 52 28	+0 41·59	...	9	14 28 55·87	9·523*n*	...	...	+2·78	...	8
4	8 41 50	+4 45·57	+ 0 0·8	12	14 28 0·83	9·534*n*	96 26 19·7	0·628	+2·78	+18·8	9
4	8 41 50	+0 6·51	− 2 38·1	12	14 28 0·71	9·534*n*	96 26 18·7	0·628	+2·79	+18·8	7
5	9 9 27	+3 49·13	− 4 9·7	10	14 27 4·40	9·459*n*	96 22 9·1	0·621	+2·79	+18·7	9
5	9 9 27	−0 49·92	...	10	14 27 4·28	9·459*n*	...	...	+2·79	...	7
6	9 16 56	+2 53·98	− 8 11·4	10	14 26 9·26	9·425*n*	96 18 7·4	0·619	+2·80	+18·7	9

Date.	Windsor Mean Time.	Planet−Star. Δ R.A.	Δ N.P.D.	No. of Comps.	Planet's App. R.A.	Log. $p\Delta$.	Planet's App. N.P.D.	Log. $p\Delta$.	Reduction to App. Place R.A.	N.P.D.	Comp. Star.
1896.	h m s	m s	′ ″		h m s		° ′ ″		s	″	
May 6	9 16 56	−1 45·12	...	10	14 26 9·099	9·425*n*	...	...	+2·80	...	7
7	9 21 34	+1 59 05	−12 4·9	10	14 25 14·33	9·395*n*	96 14 13·8	0·618	+2·80	+18·6	9
7	9 21 34	−2 39·92	...	10	14 25 14·29	9·395*n*	...	...	+2·80	...	7
8	8 53 40	+1 6·05	−15 47·3	10	14 24 21·34	9·463*n*	96 10 31·4	0·623	+2·81	+18·6	9
8	8 53 40	−3 33·06	...	10	14 24 21·16	9·463*n*	...	...	+2·81	...	7
					(22) *Calliope.*						
Sept. 21	9 40 17	−0 24·64	− 6 7·9	15	0 31 10·37	9·539*n*	108 15 31·2	0·463	+4·27	−28·1	1
22	9 19 47	−1 15·57	− 2 35·1	15	0 30 19·45	9·570*n*	108 19 4·0	0·478	+4·28	−28·1	1
23	9 32 20	−2 8·12	+ 0 52·4	10	0 29 26·90	9·536*n*	108 22 31·6	0·459	+4·28	−28·0	1
26	8 53 37	−0 4·05	−15 40 6	5	0 26 50·88	9·583*n*	108 31 33·9	0·483	+4·33	−27·5	2
27	8 49 11	−0 56·99	−13 1·7	10	0 25 57·95	9·583*n*	108 34 12 9	0·482	+4·34	−27·4	2
27	8 49 11	−1 27·54	...	10	0 25 57 97	9·583*n*	...	...	+4·33	...	3
28	9 0 45	−1 50·41	−10 31·2	13	0 25 4 50	9·552*n*	108 36 40·5	0·463	+4·34	−27·3	2
28	9 0 45	−2 21·02	...	13	0 25 4·50	9·552*n*	...	...	+4·34	...	3
30	8 50 27	−3 35·97	+ 6 17·9	10	0 23 18·99	9·553*n*	108 40 56·9	0·462	+4·35	−27·2	2
30	8 50 27	−4 6·46	...	10	0 23 19·07	9·553*n*	...	...	+4·35	...	3
Oct. 2	9 35 35	−5 23·05	− 2 52·0	6	0 21 31·92	9·412*n*	108 44 23·0	0·408	+4·37	−27·0	2
2	9 35 35	−5 53·56	...	6	0 21 31·99	9·412*n*	...	...	+4·37	...	3

Date.	Windsor Mean Time.	Planet−Star. Δ R.A.	Δ N.P.D.	No. of Comps.	Planet's App. R.A.	Log. $p\Delta$.	Planet's App. N.P.D.	Log. $p\Delta$.	Reduction to App. Place R.A.	N.P.D.	Comp. Star.
					(61) *Danaë.*						
1896.	h m s	m s	′ ″		h m s		° ′ ″		s	″	
Aug. 11	10 32 9	+5 41·60	+19 28·0	10	22 14 45·85	9·469*n*	105 56 4·1	0·481	+4·12	−18·5	1
12	9 53 32	+4 41·52	+16 47·9	10	22 13 45·78	9·548*n*	105 53 24·0	0·508	+4·13	−18·5	1
18	11 16 22	−1 44·09	− 0 43·4	10	22 7 20·24	9·131*n*	105 35 52·4	0·444	+4·20	−18·8	1
19	10 31 34	−2 46·63	− 3 42·7	10	22 6 17·71	9·339*n*	105 32 53·1	0·463	+4·21	−18·8	1
24	9 2 36	−1 3·83	+17 22·4	15	22 0 57·66	9·528*n*	105 16 53·7	0·511	+4·25	−18·3	2
26	9 47 23	−3 14·07	+10 20·6	10	21 58 47·43	9·374*n*	105 9 51·9	0·476	+4·26	−18·3	2
26	9 47 23	−0 6·75	+13 9·1	10	21 58 47·66	9·374*n*	105 9 51·5	0·476	+4·26	−18·0	3
29	9 0 2	−6 20·95	− 0 22·9	10	21 55 40·57	9·474*n*	104 59 8·4	0·495	+4·28	−18·3	2
29	9 0 2	−3 13·66	+ 2 24·6	10	21 55 40·77	9·474*n*	104 59 7 0	0·495	+4·28	−18·0	3
					(80) *Sappho.*						
Oct. 19	10 47 7	−2 36·40	− 6 56·4	14	1 44 55·59	9·145*n*	75 30 36·3	0·812	+4·40	−28·3	1
20	10 34 17	−3 22·32	+ 5 41·2	10	1 44 9 68	9·196*n*	75 43 13·8	0·810	+4·41	−28·4	1
20	10 34 17	−1 35·17	− 1 55·0	10	1 44 9·27	9·196*n*	75 43 12·7	0·810	+4·40	−28·4	2
21	10 0 23	−4 7·38	...	10	1 43 24·62	9·336*n*	...	...	+4·41	...	1
21	10 0 23	−2 20·22	+10 32·9	10	1 43 24·23	9·336*n*	75 55 40·6	0·802	+4·41	−28·4	2
					(92) *Undina.*						
Oct. 5	8 57 35	+2 0·86	− 4 10·2	16	0 47 0·14	9·532*n*	101 7 37·9	0·572	+4·27	−28·0	1
9	9 1 17	−0 56·27	+10 57 6	16	0 44 3·03	9·481*n*	101 22 46·0	0·558	+4·29	−27·7	1
10	9 50 5	−1 41·33	+14 24·4	14	0 43 17·98	9·305*n*	101 26 12·8	0·536	+4·30	−27·7	1
11	10 22 11	−2 25·45	+17 39·6	9	0 42 33·86	9·100*n*	101 29 28·1	0·525	+4·30	−27·6	1

Date.	Windsor Mean Time.	Planet − Star. Δ R.A.	Δ N.P.D.	No. of Comps.	Planet's App. R.A.	Log. $p\Delta$.	Planet's App. N.P.D.	Log. $p\Delta$.	Reduction to App. Place R.A.	N.P.D.	Comp. Star.
					(140) *Siwa.*						
1896.	h m s	m s	′ ″		h m s		° ′ ″		s	″	
July 25	9 42 0	−1 36·31	−14 36·6	10	19 50 52·11	9·405*n*	112 17 8·4	0·311	+4·30	− 4·6	1
25	9 42 0	+2 36·54	−12 20·5	10	19 50 52·03	9·405*n*	112 17 8·7	0·311	+4·30	− 4·7	2
26	9 46 41	−2 24·44	−10 26·4	8	19 50 3·99	9·370*n*	112 21 18·6	0·298	+4·31	− 4·6	1
26	9 46 41	−3 24·73	− 8 10·4	8	19 50 3·85	9·370*n*	112 21 18·8	0·298	+4·31	− 4·7	2
27	8 45 40	−3 9·53	− 6 30·8	10	19 49 18·91	9·537*n*	112 25 14·2	0·373	+4·32	− 4·6	1
27	8 45 40	−4 9·86	− 4 14·8	10	19 49 18·73	9·537*n*	112 25 14·4	0·373	+4·32	− 4·7	2
28	8 22 14	−3 55·39	− 2 33·5	10	18 48 33·06	9·576*n*	112 29 11·5	0·399	+4·33	− 4·6	1
28	8 22 14	−4 55·76	− 0 16·9	10	19 48 32·84	9·576*n*	112 29 12·3	0·399	+4·33	− 4·7	2
29	8 57 3	−4 42·57	+ 1 30·7	8	19 47 45·89	9·486*n*	112 33 15·7	0·339	+4·34	− 4·6	1
29	8 57 3	−5 42·88	+ 3 46·4	8	19 47 45·72	9·486*n*	112 33 15·6	0·339	+4·33	− 4·7	2
Aug. 1	8 34 9	+1 25·12	−17 49·1	10	19 45 33·54	9·519*n*	112 44 35·1	0·347	+4·36	− 3·6	3
1	8 34 9	−4 58·73	...	10	19 45 33·39	9·510*n*	...	...	+4·37	...	4
2	8 1 13	+0 43·87	−14 16·1	10	19 44 52·30	9·572*n*	112 48 8·1	0·389	+4·37	− 3·6	3
2	8 1 13	−5 39·98	...	10	19 44 52·14	9·572*n*	...	...	+4·37	...	4
3	9 12 15	...	−10 33·6	7	...	...	112 51 50·6	0·279	...	− 3·6	3
3	9 12 15	−6 23·33	− 7 24·5	7	19 44 8·80	9·361*n*	112 51 51·2	0·279	+4·38	− 4·3	4
4	8 39 15	−0 38·88	− 7 11·0	8	19 43 29·55	9·459*n*	112 55 13·2	0·315	+4·37	− 3·6	3
4	8 39 15	−7 2·62	− 4 2·0	8	19 43 29·51	9·459*n*	112 55 13·7	0·315	+4·38	− 4·3	4
5	8 21 57	−1 16·91	− 3 52·4	10	19 42 51·53	9·495*n*	112 58 31·8	0·332	+4·38	− 3·6	3

Adopted Mean Places of the Comparison Stars for 1896·0.

Star.	R.A.	N.P.D.	Authorities.
		(6) *Hebe.*	
	h m s	° ′ ″	
1	17 0 10·61	90 44 56·5	Lamont 5,468, Göttingen 4,178, Glasgow 1870, 4,204, Greenwich 1880, 2,665, Radcliffe 1890, 4,446.
2	16 47 44·34	89 48 37·7	Lamont 5,371, Göttingen 4,108, Yarnall$_3$ 7,114, Schjellerup 6,007, Glasgow 1870, 4,162, Glasgow 1890, 1,458, Cincinnati 1,374, Radcliffe 1890, 4,385.
3	16 44 1·26	89 53 41·7	Lamont 5,337, Göttingen 4,085, Glasgow 1870, 4,143.
4	16 39 28·75	90 8 44·5	Lamont 5,294, Göttingen 4,052, Radcliffe 1890, 4,356.
5	16 41 6·01	90 9 25·5	Radcliffe 1890, 4,364.
6	16 32 1·35	90 12 0·4	Göttingen 4,011, Radcliffe 1890, 4,315.
		(11) *Parthenope.*	
1	14 43 52·05	98 4 14·1	Radcliffe 1890, 3,831.
2	14 47 20·36	98 16 8·4	Lalande 27,076.
3	14 48 55·52	97 57 51·1	Radcliffe 1890, 3,848.
4	14 38 42 82	97 48 46·3	Radcliffe 1890, 3,807.
5	14 40 41·78	97 21 30·0	Radcliffe 1890, 3,819.
6	14 33 5·65	96 42 37·0	Radcliffe 1890, 3,786.
7	14 27 51·41	96 28 38·0	Radcliffe 1890, 3,766.
8	14 28 11·50	96 24 40·2	Lalande 26,549, Lamont 1,715.
9	14 23 12·48	96 26 0·1	Greenwich 1880, 2,243, Stone 7,891, Radcliffe 1890, 3 751.

Star.	R.A.	N.P.D.	Authority.
			(22) *Calliope.*
	h m s	° ′ ″	
1	0 31 30·74	108 22 7·2	Six filar-micrometer Comps. with β Ceti, 1896 Oct. 16.
2	0 26 50·60	108 47 42·0	Arg.-Oeltzen 245–6, Radcliffe 1893, 101.
3	0 27 21·18	108 41 0·4	Arg.-Oeltzen 248–9.
			(61) *Danaë.*
1	22 9 0·13	105 36 54·6	Yarnall$_3$ 10,026, Radcliffe 1890, 5,980.
2	22 1 57·24	104 59 49·6	Lalande 43,108–9, Lamont 1,488, Arg.-Oeltzen 21,904, Yarnall$_3$ 9,957, Radcliffe 1890, 5,949.
3	21 58 50·15	104 57 0·4	Lalande 43,009, Lamont 1,486.
			(80) *Sappho.*
1	1 47 27·59	75 38 1·0	Yarnall$_3$ 900.
2	1 45 40·04	75 45 36·1	Yarnall$_3$ 884.
			(92) *Undina.*
1	0 44 55·01	101 12 16·1	Radcliffe 1860, 91, Yarnall$_3$ 436, Greenwich 1864, 99, Quetelet 332, Arg. Gen. Cat. 757, Stone 328, Radcliffe 1890, 168.
			140 *Siwa.*
1	19 52 24·12	112 31 49·6	Arg.-Oeltzen 20,116, Arg. Gen. Cat. 27,328.
2	19 53 24·27	112 29 33·9	Arg.-Oeltzen 20,131, Arg. Gen. Cat. 27,360, Radcliffe 1890, 5,344.
3	19 44 4·06	113 2 27·8	Arg.-Oeltzen 19,992–3, Arg. Gen. Cat. 27,150, Radcliffe 1890, 5,298.
4	19 50 27·75	112 59 20·4	Arg. Gen. Cat. 27,286.

Private Observatory, The Peninsula, Windsor, N.S. Wales:
1896 *October* 29.

Observations of Comet f 1896 (*Perrine*) *made at the Royal Observatory, Greenwich.*

(*Communicated by the Astronomer Royal.*)

The observations were made with the Sheepshanks Equatorial, aperture 6·7 inches, by taking transits over two cross-wires to right angles to each other, and each inclined 45° to the parallel of declination. Magnifying power, 55.

Greenwich Mean Solar Time.					Observer.	☄ − ✱ R.A.	Corr. for Refraction.	Log. factor of Parallax.	☄ − ✱ N.P.D.	Corr. for Refraction.	Log. factor of Parallax.	No. of Comps.	Apparent R.A. of ☄	Apparent N.P.D. of ☄	Comp. Star.
1896.	d	h	m	s		m s	s		′ ″	″			h m s	° ′ ″	
Nov.	29	7	22	12	B.	+0 34·54	0·00	9·5122	−1 24·5	0·0	0·8129	4	19 54 9·76	82 44 21·9	*a*
	30	6	9	59	C. D.	−1 12·66	+0·01	9·4122	−6 45·5	−0·1	0·8046	5	19 53 44·03	83 13 34·9	*b*
	30	6	14	4	,,	−1 8·66	−0·01	9·4201	+9 37·5	+0·3	0·8052	4	19 53 43·54	83 13 31·8	*c*
Dec.	4	5	30	18	,,	−0 1·45	−0·01	9·3617	+7 1·5	+0·1	0·8132	3	19 52 11·74	85 10 48·0	*d*
	4	5	48	32	,,	−0 42·91	+0·01	9·4027	−9 26·7	−0·3	0·8149	3	19 52 12 63	85 11 3·4	*e*

Notes.

The observations are corrected for refraction, but not for parallax. They are also corrected for the error of inclination of the wires and for the motion of the Comet.

November 29.—The Comet had a fairly defined nucleus.

November 30.—The Comet had a well-defined nucleus.

December 4.—There was no nucleus visible. The presence of a small star a little south preceding the centre of the Comet made observation difficult.

The initials B. and C. D. are those of Mr. Bryant and Mr. Davidson respectively.

Comparison Stars.

	Star's Name.	Assumed R.A. 1896·0. h m s	Assumed N.P.D. 1896·0. ° ′ ″	Authority.
a	W.B. XIX. 1294	19 53 32·88	82 45 56·2	Munich Catalogue 1880.
b	Lalande 38148	19 54 54·32	83 20 30·2	Yarnall, Munich and Bonn Observations, vol. vi.
c	W.B. XIX. 1321	19 54 49·86	83 4 3·8	Brussels 1865, and Bonn Observations, vol. vi.
d	B.D. +4° No. 4286	19 52 10·83	85 3 54·9	Albany Astr. Gesell, Munich, and Schjellerup's Catalogues.
e	B.D. +4° No. 4292	19 52 53·15	85 20 38·9	Albany Astr. Gesell Catalogue.

Note.—In Lalande's Catalogue the N.P.D. of 38144 belongs to 38148, and *vice versa*.

Royal Observatory, Greenwich:
1896 *December* 11.

Observation of Brooks' Periodic Comet 1896 *c* (1889 V) *at the Radcliffe Observatory, Oxford.*

(*Communicated by E. J. Stone, Esq., M.A., F.R.S., Radcliffe Observer.*)

The following comet observation was made with the 10-inch Barclay Equatorial, using the ring-micrometer with power 100.

Date.	G.M.T.	Local Sidereal Time.	Observer.	Comet *minus* Star (corrected for Refraction only). R.A.	N.P.D.	No. of Comps.	Apparent R.A. of Comet.	Parallax in R.A. *p*.	Log. ($p \times \Delta$).	Apparent N.P.D. of Comet.	Parallax in N.P.D. *q*.	Log. ($q \times \Delta$).
1896.	h m s	h m s		m s	′ ″		h m s	s		° ′ ″	″	
Oct. 9	9 56 12	23 7 11	R.	+1 19·39	−1 11·2	9	22 9 4·02	+0·08	8·9786	106 26 44·6	7·0	0·9098

Observer's Remarks.

The Comet is about 1′ in diameter, and has a faint but distinct nucleus.

Observer : Mr. W. H. Robinson.

Assumed Place of the Comparison Star.

Mean R.A. 1896.	Reduction to Apparent R.A.	Mean N.P.D. 1896.	Reduction to Apparent N.P.D.	Authority.
h m s	s	° ′ ″	″	
22 7 40·45	+4·18	106 28 12·9	−17·1	Radcliffe Transit-circle observation, 1896 October 31.

In the computation of the parallaxes the adopted value of the Sun's mean horizontal parallax is 8″·85; and the geocentric distance, Δ, is taken from the *Astronomische Nachrichten*, No. 3,378.

Radcliffe Observatory, Oxford:
1896 *December* 10.

Ephemeris for Physical Observations of the Moon, 1897 January to August. By A. Marth.

Greenwich Noon.	Selenographical Colong.	Selenographical Lat. of the Sun.	Geocentric Libration Sel. Long.	Geocentric Libration Lat. of the Earth.	Combined Amount.	Direction.
1897.	°	°	°	°	°	°
Jan. 7	317·12	−0·75	+5·07	−2·74	5·76	241·6
8	329·30	·73	4·26	4·00	5·84	226·7
9	341·47	·71	3·22	5·06	6·00	212·4
10	353·63	·69	2·03	5·88	6·22	198·9
11	5·79	·66	+0·75	6·44	6·48	186·6
12	17·94	·64	−0·53	6·73	6·75	175·5
13	30·09	−0·61	−1·73	−6·72	6·94	165·6
14	42·23	·58	2·80	6·42	7·00	156·5
15	54·37	·55	3·69	5·83	6·89	147·8
16	66·50	·52	4·34	4·95	6·58	138·8
17	78·63	·49	4·75	3·80	6·08	128·7
18	90·76	·46	4·91	2·43	5·48	116·4
19	102·89	−0·43	−4·81	−0·90	4·89	100·6
20	115·02	·40	4·48	+0·70	4·54	81·1
21	127·15	·37	3·95	2·29	4·56	59·8
22	139·29	·34	3·23	3·77	4·96	40·6
23	151·43	·31	2·37	5·03	5·56	25·2
24	163·58	·28	1·41	5·99	6·15	13·2
25	175·73	−0·25	−0·38	+6·60	6·61	3·3
Feb. 6	321·95	+0·06	+2·02	−5·69	6·04	199·5
7	334·13	·09	+0·86	6·34	6·40	187·7
8	346·30	·11	−0·40	6·71	6·72	176·6
9	358·47	·14	1·67	6·80	7·00	166·3
10	10·64	·17	2·89	6·59	7·19	156·5
11	22·80	·20	3·98	6·09	7·27	147·0
12	34·95	+0·23	−4·87	−5·31	7·20	137·6
13	47·10	·26	5·50	4·26	6·95	127·8
14	59·24	·29	5·82	2·97	6·53	117·1
15	71·38	·32	5·80	−1·48	5·98	104·4
16	83·52	·35	5·42	+0·12	5·42	88·7
17	95·65	·39	4·70	1·77	5·02	69·3
18	107·79	+0·42	−3·70	+3·32	4·96	48·0
19	119·93	·45	2·45	4·67	5·29	27·6

Greenwich Noon.	Selenographical Colong. of the Sun.	Lat.	Geocentric Libration Sel. Long. of the Earth.	Lat.	Combined Amount.	Direction.
1897.	°	°	°	°	°	°
Feb. 20	132·07	+0·48	−1·10	5·77	5·87	10·7
21	144·22	·50	+0·29	6·47	6·48	357·5
22	156·38	·53	1·60	6·77	6·95	346·8
23	168·54	·56	2·76	6·64	7·18	337·5
24	180·70	+0·58	+3·72	+6·10	7·14	328·8
Mar. 6	302 68	+0·80	+1·13	−6·10	6·21	190·4
7	314·88	0·83	−0·06	6·55	6·55	179·5
8	327·08	0·85	1·32	6·71	6·84	168·9
9	339·27	0·87	2·60	6·58	7·08	158·5
10	351·45	0·89	3·85	6·17	7·27	148·1
11	3·63	+0·92	−5·01	−5·49	7·42	137·7
12	15·81	0·94	5·96	4·54	7·49	127·4
13	27·98	0·97	6 66	3·36	7·46	116·9
14	40·15	0·99	7·02	1·99	7·29	105·8
15	52·31	1·01	6·98	−0·46	7·00	93·8
16	64·47	+1·04	−6·50	+1·14	6·60	80·1
17	76·62	1·06	5·57	2·71	6·19	64·0
18	88·77	1 09	4·24	4·16	5·93	45·5
19	100·92	1·11	2·58	5·35	5·94	25·6
20	113·07	1·13	−0·76	6·19	6·24	6·9
21	125·22	+1·15	+1·10	+6·61	6·70	350·6
22	137·38	1·17	2·80	6·58	6·14	337·0
23	149·55	1·19	4·25	6·11	7·44	325·4
24	161·72	1·20	5·34	5·28	7·50	314·8
25	173·90	+1·21	+6·04	+3·86	7·33	304·6
Apr. 5	308·23	+1·35	−1·79	−6·48	6·72	164·6
6	320·44	1·37	3·09	6·12	6·85	153·3
7	332·65	1·38	4·35	5·49	7·01	141·7
8	344·86	1·39	5·53	4·62	7·20	130·0
9	357·06	1·40	6·55	3·52	7·43	118·3
10	9·25	1·42	7·33	2·24	7·66	107·0
11	21·44	+1·43	−7·79	−0·81	7·83	96·0
12	33·63	1·44	7·84	+0·70	7·87	84·9
13	45·81	1·45	7·42	2·23	7·74	73·2
14	57·98	1·46	6·50	3·67	7·46	60·4
15	70·15	1·47	5·09	4·92	7·07	45·8

Greenwich Noon.	Selenographical Colong. of the Sun.	Lat.	Geocentric Libration Sel. Long. of the Earth.	Lat.	Combined Amount.	Direction.
1897.	°	°	°	°	°	°
Apr. 16	82·32	+1·48	−3·27	+5·87	6·71	29·0
17	94·48	1·49	−1·18	6·42	6·53	10·4
18	106·65	1·50	+0·98	6·52	6·59	351·5
19	118·82	1·50	3·02	6·15	6·85	333·9
20	130·99	1·51	4·76	5·38	7·18	318·6
21	143·17	1·51	6·08	4·27	7·42	305·1
22	155·36	1·51	6·93	2·93	7·52	293·0
23	167·55	+1·51	+7·32	+1·46	7·46	281·3
May 5	314·25	+1·51	−4·38	−4·63	6·32	136·3
6	326·48	1·51	5·52	3·56	6·56	122·9
7	338·71	1·51	6·52	2·32	6·92	109 6
8	350·93	1·51	7·30	−0·94	7·36	97·3
9	3·14	1·51	7·80	+0·52	7·82	86·2
10	15·35	1·51	−8·04	1·99	8·28	76·0
11	27·55	1·50	7·63	3·40	8·35	65·9
12	39·74	1·50	6·83	4·65	8·26	55·6
13	51·93	1·50	5·54	5·66	7·92	44·3
14	64·12	1·49	3·81	6·31	7·37	31·0
15	76·30	+1·48	−1·77	+6·54	6·78	15·0
16	88·48	1·48	+0·42	6·31	6·32	356·2
17	100·66	1·47	2·55	5·63	6·18	335·7
18	112·84	1·46	4·43	4·56	6·36	315·9
19	125·02	1·45	5·92	3·21	6·73	298·5
20	137·21	1·43	6·93	1·70	7·13	283·8
21	149·41	1·42	7·45	+0·14	7·45	271·0
22	161·62	1·41	7·50	−1·38	7 62	259·5
23	173·83	1·40	7·15	2·79	7·67	248·6
24	186·04	+1·38	+6·48	−4·02	7·62	238·1
June 4	320·68	+1·25	−6·01	−1·04	6·10	99·8
5	332·92	1·23	6·68	+0·42	6·85	86·4
6	345·15	1·22	7·07	1·88	7·49	75·1
7	357·37	1·21	7·19	3·28	7·90	65·4
8	9·59	1·19	6·91	4·54	8·26	56·5
9	21·80	1·18	6·24	5·58	8·36	48·1
10	34·01	1·16	5·14	6·30	8·12	39·0
11	46·21	1·14	3·65	6·64	7·57	28·7

Greenwich Noon.	Selenographical Colong. of the Sun.	Lat.	Geocentric Libration Sel. Long. of the Earth.	Lat.	Combined Amount.	Direction.
1897.	°	°	°	°	°	°
June 12	58·41	+1·12	−1·90	+6·54	6·81	16·1
13	70·60	1·10	+0·07	5·99	5·99	359·3
14	82·79	1·08	2·01	5·02	5·41	338·3
15	94·98	1·06	3·77	3·72	5·30	314·6
16	107·17	1·04	5·23	2·19	5·66	292·8
17	119·36	1·01	6·27	+0·56	6·30	275·1
18	131·56	0·99	6·87	−1·05	6·95	261·3
19	143·76	0·97	7·02	2·56	7·47	249·9
20	155·97	0·94	6·77	3·89	7·80	240·0
21	168·18	0·92	6·17	4·99	7·93	230·9
22	180·40	+0·90	+5·30	−5·83	7·87	222·1
July 6	351·80	+0·60	−5·46	+5·52	7·76	44·6
7	4·02	0·58	4·78	6·30	7·90	37·0
8	16·24	0·55	3·80	6·71	7·71	29·4
9	28·45	0·53	2·56	6·72	7·19	20·8
10	40·66	0·50	−1·13	+6·31	6·41	10·1
11	52·86	0·47	+0·41	5·47	5·49	355·7
12	65·05	+0·45	1·94	4·28	4·70	335·6
13	77·24	0·42	3·36	2·81	4·38	310·0
14	89·43	0·39	4·55	+1·18	4·70	284·6
15	101·62	0·36	5·44	−0·49	5·46	264·9
16	113·82	0·33	5·97	2·09	6·32	250·7
17	126·01	0·30	6·03	3·53	6·98	239·6
18	138·21	+0·27	+5·92	4·74	7·58	231·2
19	150·42	0·24	5·38	5·69	7·83	223·3
20	162·63	0·21	4·57	−6·36	7·82	215·6
21	174·85	0·18	3·53	6·72	7·59	207·6
22	187·07	0·16	2·35	6·77	7·17	199·1
23	199·30	0·13	+1·09	6·66	6·75	189·3
24	211·53	0·10	−0·18	6·06	6·06	178·3
25	223·77	+0·08	−1·40	−5·29	5·47	165·2
Aug. 5	358·43	−0·18	−1·80	+6·79	7·02	14·8
6	10·64	0·21	−0·74	6·47	6·51	6·5
7	22·85	0·24	+0·43	5·75	5·76	355·7
8	35·05	0·27	1·55	4·67	4·92	341·7
9	47·25	0·30	2·63	3·31	4·23	321·6
10	59·44	0·33	3·58	1·76	3·99	296·2
11	71·63	0·36	4·36	+0·11	4·36	271·5

Greenwich Noon.	Selenographical Colong. of the Sun.	Lat. of the Sun.	Geocentric Libration Sel. Long. of the Earth.	Lat. of the Earth.	Combined Amount.	Direction.
1897.	°	°	°	°	°	°
Aug. 12	83·81	−0·39	+4·91	−1·51	5·14	252·9
13	96·00	0·42	5·21	3·02	6·02	239·9
14	108·18	0·45	5·23	4·33	6·78	230·3
15	120·37	0·48	4·96	5·38	7·31	222·6
16	132·56	0·50	4·41	6·15	7·56	215·5
17	144·76	0·53	3·60	6·61	7·52	208·4
18	156·96	0·56	2·58	−6·77	7 24	200·8
19	169·16	0·58	1·41	6·63	6·78	191·9
20	181·37	0·61	+0·15	6·20	6·21	181·3
21	193·59	0·63	−1·13	5·51	5·63	168·4
22	218·82	0·65	2·35	4·58	5·14	152·9
23	230·05	0·67	3·44	3·43	4·85	135·0
24	242·29	−0·69	−4·30	−2·10	4·78	116·1

In the general list of published and properly timed lunar photographs and sketches, referred to in the last ephemeris, *Monthly Notices*, vol. lvi. p. 159, the photographs will be arranged according to the Sun's selenographical positions, and the topocentric librations or the selenographical positions of the places of observing will be added, so that the varying effects of the foreshortening may be duly taken into account For the present I must content myself with making an addition to the old list published in vol. li.

The photographs now inserted are those published in vol. xxxii. part 1 of the Annals of the Harvard College Observatory, those in vol. iii. of the Publications of the Lick Observatory, and the few in *Knowledge*, of which the times are known. The Lick references are :

	Sel. Long. of the Sun.	Lat. of the Sun.	Pacific Standard T.		
	″	°	h m s		
Lick 1	15·72	+1·15	1891 July 14	8 12 26·5	Lick, vol. iii.
2	33·98	+0·97	1891 Oct. 12	7 30 54·5	,,
3	115·43	+1·51	1890 Aug. 31	14 27	,,
4	172·48	−0·91	1895 Oct. 9	16 36 20	Knowl. 95 Oct. Dec.
5	173·00	−0·35	1892 Nov. 10	15 52 41	Lick, vol. iii.
6	184·77	−0·93	1895 Oct. 10	16 49 13 8	Plate 1 of Obs. Atlas.
7	190·10	+1·37	1891 July 28	15 49 16	Lick, vol. iii.

The time of the Paris photograph in *Knowledge* for '95 June and '96 April should be 1894 March 14, $7^h\ 4^m{\cdot}5$ Paris mean time, as M. Puiseux has kindly informed me, the inserted time being approximately sidereal. The sketches referred to in the list are found in the reports of the Lunar Section of the British Astronomical Association, or in the *Observatory* of 1896.

Sun's Colong. ☉'s Lat.	Sun's Colong.	Lat.	Spot.	Gr. M.T.				
						h	m	
32·50 + 0·560 ×	331·86	− 1·14	Piccolomini	1892 Jan.	4	5	15	Elger.
37·15 + 0·201	337·17	+ 0·07	Theophilus	93 Apr.	21	8	42·5	Gordon.
38·28 + 0·201	338·48	+ 1·00	Theophilus	94 May	10	8	15	Mee.
55·13 − 0·258	354·79	+ 1·34	Manilius	96 Jan.	17	9	30	Elger. Obs. p. 302.
2·48 − 0·304	2·62	− 0·46	Plinius	94 Mar.	14	Paris		Knowl. 1895 June.
2·71 + 0·202	,,	,,	Albategnius	,,		,,		,, 1896 April.
3·07 + 0·986	,,	,,	Maurolycus	,,		,,		,, ,,
3·17 + 1·200	,,	,,	Cuvier	,,		,,		,, 1895 June.
7·75 + 0·390	8·09	+ 0·88	Thebit	90 May	24	9	10	Corder.
11·39 + 0·330	11·80	+ 1·23	Arzachel	88 Sept.	13	16	2	Harvard, vi. 5.
11·51 + 0 233	,,	,,	Alphonsus	,,		,,		,, vi. 5.
13·39 − 0·409	12·77	+ 1·53	Conon	89 Oct.	2	15	19	,, vi. 1.
13·58 − 0·529	,,	,,	Archimedes	...		...		,, vi. 1.
16·02 − 0·258	15·72	+ 1·15	Eratosthenes	91 July	14	...		Lick 1.
16·19 − 0·415	...		Conon	—		—		—
16·30 − 0·594	...		Timocharis	—		—		—
16·30 − 0·533	...		Archimedes	—		—		—
16·52 − 0·701	...		Aristillus	—		—		—
16·76 − 0·910	15·72	+ 1·15	Cassini	91 July	14	...		Lick, 1.
23·33 + 0·350	23·77	+ 1·24	Arzachel	88 Sept.	14	15	36	Harvard, vi. 6.
23·46 + 0·246	,,		Alphonsus	,,		,,		,, ,,
32·70 − 0·057	32·62	+ 1·37	Reinhold	89 Sept.	4	18	6	,, v.
32·85 − 0·169	,,		Copernicus	,,		,,		,, ,,
34·14 − 0·170	33·98	+ 0·97	Copernicus	91 Oct.	12	(frontispiece)		Lick, 2.
37·65 − 0·429	37·30	+ 0·81	Euler	96 Mar.	24	9	45	Elger. Obs. p. 440.
49·28 − 0·203	49·11	+ 0·84	Marius	96 Mar.	25	9	2·5	Elger. Obs. p. 329.
52·03 − 0·432	52·53	− 1·15	Aristarchus	94 Nov.	9	8	37·5	Sheldon.
64·41 + 0·093	64·49	+ 0·90	Damoiseau	87 Dec.	27	8	30	Elger. Obs. p. 399.
03·35 + 1·632	105·69	+ 1·45	Endymion	89 Sept.	10	18	8	Harvard, vi. 3.
03·80 + 1·329	,,		Hercules	,,		,,		,, ,,
13·09 − 0·463	113·67	− 1·25	Petavius	94 Nov.	14	9	30	Sheldon.
13·57 − 0·354	113·85	− 0·80	Vendelinus	91 Dec.	17	9	15	Elger.
14·42 + 0·674	115·43	+ 1·51	Geminus	90 Aug.	31	...		Lick, 3.
14·66 + 0·515	...		Cleomedes	—		—		—
15·03 + 0·265	...		Prom. Agarum	—		—		—

Sun's Colong. c	⊙'s	Sun's Colong. °	Lat. °	Spot.	Gr. M.T. h m		
115·65 − 0·148	,,	...		Langrenus	—	—	—
115·72 − 0·187	,,	...		Goclenius	—	—	—
115·96 − 0·353	,,	...		Vendelinus	—	—	—
116 13 − 0·460	,,	...		Petavius	—	—	—
116·42 − 0·655	,,	115·43 + 1·51		Furnerius	90 Aug. 31	...	Lick, 3.
117·51 − 0·353	,,	117·58 − 0·21		Vendelinus	92 Nov. 6	10 30	Elger.
123·77 + 1·511	,,	123·94 + 0·11		Endymion	88 July 25	21 52	Harvard, vi. 4.
123·82 + 1·102	,,	,,		Hercules	,,	,,	,, ,,
126·87 − 0·035	,,	126 82 − 1·27		Messier	94 Nov. 15	11 30	Mee.
138·53 − 0·569	,,	139·01 − 0·85		Piccolomini	94 Dec. 19	11 0	Elger.
144·39 − 0·552	,,	144·20 + 0·34		Piccolomini	93 Sept. 29*	10 30	Davis.
169·91 − 2·839	,,	172·48 − 0·91		Moretus	95 Oct. 9	Lick 4	Knowl. 1896 Oct.
170·54 − 2·140	,,	...		Scheiner	...	...	,, ,,
170·94 − 1·700	,,	...		Clavius	...	...	,, ,,
171·36 − 1·236	,,	...		Maginus	...	...	,, Oct., Dec.
171·45 − 1·411	,,	...		Wilhelm I.	...	...	,, ,, ,,
171·58 − 0 990	,,	...		Tycho	...	...	,, ,, ,,
171·89 − 0·651	,,	...		Hell	...	...	,, ,,
171·92 − 0·616	,,	172·48 − 0·91		Walter	95 Oct. 9	...	,, ,,
172·66 − 0·983	,,	173·00 − 0·35		Tycho	92 Nov. 10	...	Lick 5.
180·05 − 5·12	,,	184·77 − 0·93		Newton	95 Oct. 9	...	Lick 6.
182·24 − 2·722	,,	...		Moretus	—	—	—
183·84 − 2·083	,,	...		Blancanus	—	—	—
183·03 − 1·886	,,	...		Scheiner	—	—	—
183·30 − 1·588	,,	...		Clavius	—	—	—
183·46 − 1·413	,,	...		Longomontanus	—	—	—
183·66 − 1·192	,,	...		Maginus	—	—	—
183·90 − 0·937	,,	...		Tycho	—	—	—
184·10 − 0·789	,,	...		Capuanus	—	—	—
184·13 − 0·687	,,	...		Cichus	—	—	—
184·19 − 0·626	,,	...		Hell	—	—	—
184·24 − 0·571	,,	184·77 − 0·93		Pitatus	95 Oct. 9	...	Lick 6.
190·19 + 0·167	,,	190·42 + 1·37		Copernicus	91 July 28	...	Lick 7.
217·81 + 0·437	,,	218·48 + 1·50		Aristarchus	89 Sept. 20	0 9	Harvard vi. 2.

* The right date is Sept. 29, not Sept. 3.

In order to ascertain the time when for a spot on the list the Sun is at the same zenith distance as at the time assigned to the photograph or sketch, it is only required to multiply the Sun's selenographical latitude (taken from the ephemeris for the approximate time of the occurrence) by the factor given in the second column of the list, to add the product to the Sun's colongitude (for latiude 0°) in the first column, and to determine, by reference to the ephemeris, the time when the Sun reaches the colongitude thus found. Though the Sun's zenith distance will then be the same as at the time of the photograph or sketch, the effects of the illumination may yet differ sensibly, as they depend also on the Sun's azimuth, and they will therefore only agree if the Sun's latitude is the same on both occasions.

As the daily rate of increase of the Sun's colongitude is between 12°·12 and 12°·25, the ephemeris is sufficiently accurate for finding the time to about a minute. But the time thus found is merely that corresponding to the assigned time of the photograph or sketch, and any error or vagueness of the assigned time is simply reproduced. If the evidence of the sketches is to be used for determining the proper times for measuring the shadows, it is clearly essential that the correct times should be stated when the outlines of the shadows have actually been drawn.

The following are the times of recurrences for a few of the spots in the preceding list, to which is added *Plato* as sketched by M. Elger, 1887 February 1, inserted in the old list of 1891, and also referred to in vol. xlviii. p. 294.

	1897. h m	h m	h m	h m
Piccolomini	Jan. 8 5 30	Feb. 6 20 53	Mar. 8 11 37	Apr. 7 1 13
Theophilus	8 15 12	7 6 0	8 20 10	7 9 24
Manilius	10 3 19	8 17 12	10 6 48	8 19 30
Plinius	10 17 53	9 7 49	10 21 11	9 9 49
Albategnius	10 17 40	9 8 25	10 22 33	9 11 41
Maurolycus	10 17 21	9 9 22	11 0 41	9 14 34
Cuvier	10 17 16	9 9 39	11 1 14	9 15 21
Thebit	11 3 21	9 18 25	11 8 50	9 22 8
Plato	11 13 36	10 2 4	11 14 4	10 1 50
Eratosthenes	11 20 33	10 10 31	11 23 56	10 12 36
Timocharis	11 21 24	10 11 0	12 0 2	10 12 28
Aristillus	11 22 5	10 11 20	12 0 6	10 12 19

	1897.	h m		h m		h m		h m
Piccolomini	May	6 13 28	June	4 22 34	July	...	Aug.	...
Theophilus		6 21 32		5 8 47		...		...
Manilius		8 7 29		6 19 0		6 6 15		4 17 36
Plinius		8 21 48		7 9 19		6 20 38		5 8 5
Albategnius		8 23 45		7 10 58		6 21 40		5 8 20
Maurolycus		9 2 47		7 13 31		6 23 15		5 8 45
Cuvier		9 3 37		7 14 10		6 23 43		5 8 52
Thebit		9 10 13		7 21 18		7 7 46		5 18 10
Plato		9 13 37		8 1 42		7 14 7		6 2 58
Eratosthenes		10 0 33		8 12 2		7 23 18		6 10 42
Timocharis		10 0 22		8 12 0		7 23 34		6 11 21
Aristillus		10 0 13		8 11 58		7 23 48		6 11 52

Col. Cooper's Observatory:
Markree, Collooney, Ireland.